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TECHNICAL MANUAL

PRECISE ASTRONOMIC SURVEYS

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HEADQUARTERS, DEPARTMENT OF THE ARMY
AUGUST 1970

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TECHNICAL MANUAL
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HEADQUARTERS
DEPARTMENT OF THE ARMY
WASHINGTON, D.C., *4 August 1970*

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CHAPTER 1

INTRODUCTION

1-1. Purpose and Scope

a. This manual provides both a training text and specifications for the determination of precise astronomic position and azimuth. It may be used as a reference for those interested in, or responsible for, astronomic position and azimuth determinations.

b. This manual is not concerned with basic practical astronomy. Personnel using this manual as a training text must have a basic knowledge of the inter -relationship of astronomic coordinate systems, and the theory and conversion of time as related to astronomy. Trainees must be able to perform mathematical computations involving algebra and plane and spherical trigonometry, and must be proficient in the use of the desk calculator. A thorough understanding of topographic surveys is a distinct advantage.

c. The manual deals with the operation of the Wild T-4 Theodolite and the allied equipment that is used in the astronomic position determination, and the Wild T-3 Theodolite used for astronomic azimuth determination.

d. Some theory is discussed in detail, but this manual does not attempt to present a comprehensive theoretical development of the subject matter. For those desiring a more thorough treatment of theory, the references listed in appendix A are recommended.

e. Each computation is explained in the text. The computation methods described and illustrated result in complete office reductions. Where only a field reduction is required, many of the minor steps and refinements may be omitted.

f. Users of this manual are encouraged to submit recommended changes or comments to improve the manual. Comments should be keyed to the specific page, paragraph, and line of the text for which the change is recommended. Reasons should be provided for each comment to insure understanding and complete evaluation. Comments should be forwarded directly to the Commandant, U. S. Army Engineer School, Fort Belvoir, Va., 22060.

g. The material presented in this manual is applicable to both nuclear and nonnuclear warfare.

1-2. General

The prescribed methods for determining precise astronomic positions and azimuth vary somewhat among the various agencies of the U. S. government and even more among the agencies of foreign governments. The specifications contained herein meet or exceed the present requirements of all these agencies.

1-3. Operations and Equipment

a. The astronomic party generally operates independently as a very small group. The field party must carry sufficient equipment to operate without external support of any type for short periods of time (2 to 4 weeks) and with only minimum support for longer periods (3 to 6 months). Funds must be available to purchase goods and services that cannot be provided by the support element without undue delay of operations.

b. A major consideration for successful observations is the assembly of satisfactory electronic timing equipment. Chapter 4 discusses in detail necessary modifications of issued components and the assembly of additional equipment.

1-4. Reliability of Results

Accuracies of results can be achieved only when specifications and prescribed methods are carefully followed, probable errors are satisfactory, and the observers are experienced and reliable. To determine if an individual can produce first order results, his observations at three to five previously determined astronomic stations must be compatible with their published positions and azimuths. If they are not, such an individual probably lacks the necessary visual acuity for precise astronomic observations, and further training as an observer is not advisable.

1-5. Training

A minimum of 6 months of intensive training of otherwise well qualified surveyors is required to produce a qualified, reliable astronomic team. Training time can be reduced by introducing one or two trainees into an experienced team, rather than attempting to train an entire team of inexperienced men. All members of the team should be trained in all functions so that duties may be interchanged when necessary. It is desirable, although not necessary, that all men be equally qualified in all phases of field operations.

1-6. Records

a. Preparation. All permanent records incidental to the operation are recorded with permanent black or blue-black ink which is suitable for photographic copying. Ball point pens are recommended. Field records are not transcribed from one book to another. If it is necessary to change a figure, a diagonal line is drawn through the incorrect entry and the correct figure written above or below. All records must be neat, accurate, and thoroughly checked. Every page contains the recorder's name and the checkers initials, and any changes made by the checker are checked by the recorder. DA Forms referenced will be procured through normal AG Supply channels, with the exception of DA Forms 3618, 3619, 3620 and 3621, which will be reproduced locally.

b. Transmittal. Field records and computations are transmitted as two separate shipments. Whenever possible the records are sent by registered mail. If registered mail is not available the most secure means possible is used. Postal services of foreign governments are avoided and the pouch service of the U.S. State Department is used if necessary.

(1) The first shipment consists of diagrams, original forms, chronograph records, instrument constants, preliminary station report, station recovery data, station descriptions, and any other data required for the final computations.

(2) After the first shipment has been received by the addressee, the checked abstracts, computations, observing list, any duplications, and a final station report are sent.

c. Station Report. The station report consists of two parts:

(1) Part one contains a list, by item name and/or number, and the quantity of all items included in that shipment.

(2) Part two contains all information pertinent to the station and observations, e.g., field results, types of equipment used, problems with time signals and/or equipment, instrument constants, etc. The station report accompanying the final shipment need only include any changes or additions to the initial station report.

1-7. Notation

a. In cases where a mean of several values is to be determined, the residuals will usually be found also. Throughout this manual any residual is symbolized as "v" and any v is found from v = (mean value) minus (any individual value used in determining the mean). Hence,

$$m = \frac{m_1 + m_2 + m_3 \ldots . + m_n}{n}$$

$$v_1 = m - m_1$$

$$v_2 = m - m_2$$

$$v_3 = m - m_3$$

$$\cdot \ \cdot \ \cdot \ \cdot \ \cdot \ \cdot$$

$$v_n = m - m_n$$

In which:

m = the arithmetic mean

m_1 etc. = the individual values

n = the number of values

v_1 etc. = the individual residuals

The algebraic sum of the residuals so determined should, theoretically, be equal to zero. However, due to round off, the ideal value is seldom attained. Nevertheless, the algebraic sum of the residuals must never exceed n/2 times the least decimal value in which the mean is expressed. Assuming nine residuals with values expressed to 0″.001, the algebraic sum cannot exceed 0″.0045 or 0″.005. If this value is exceeded an error has been made.

b. Throughout this manual the brackets [ ] are used to symbolize an algebraic summation of the inclosed quantity. For instance:

$$[v] = v_1 + v_2 + v_3 \ldots . + v_n$$

$$[vv] = (v_1)(v_1) + (v_2)(v_2) + (v_3)(v_3) \ldots . + (v_n)(v_n)$$

$$[v]\,[v] = (v_1 + v_2 + v_3 \ldots . + v_n)^2$$

1-8. Catalogue Abbreviations

The following is a list of abbreviations used throughout this text for appropriate star catalogues and ephemerides.

AE&NA	The *American Ephemeris and Nautical Almanac* contains ephemerides for the Sun, Moon, and planets, plus tables for Universal, Ephemeris, and sidereal times, tables of the Besselian and Independent Day Numbers, and other associated tables useful in astronomic computations.
FK4	The *Fourth Fundamental Catalogue* contains the mean positions and proper motion of 1535 fundamental stars.

APFS	The *Apparent Places of Fundamental Stars* contains the apparent places of the 1535 stars of the FK4 and is published yearly.
GC	The *Boss General Catalogue of 33,342 Stars for the Epoch 1950* contains the mean positions, with sufficient additional terms to facilitate computations to apparent positions through the use of Besselian Day numbers.
SAO	The *Smithsonian Astrophysical Observatory Star Catalogue* contains the mean position and proper motion of 258,000 stars through the 12th magnitude. These stars have been compiled from all other major catalogues and tabulated with reference to the FK4 system.

CHAPTER 2

WILD T-4 THEODOLITE

2-1. General

The Wild T-4 theodolite (figs. 2-1 and 2-2), although large and heavy, is nevertheless basically the same as any other theodolite instrument. Since the observations must be of great accuracy, the size and weight are an advantage rather than a handicap. The primary assemblies of the T-4 are the base and yoke, the telescope with vertical circle, the Horrebow-Talcott levels, the eyepiece micrometer, and the hanging level. Several minor modifications of the T-4 have been made.

2-2. Description of Components

a. Packing Cases. The Wild T-4 theodolite and accessories, less the tripod, are packed in five boxes. The instrument is packed in two cases, the base and yoke in one and the telescope in the other. The other three boxes are the hanging level case, the accessory case, and the battery box. The cases are reinforced with metal corners and edges and are fitted with blocks and stops that hold the instrument firmly in place when the cases are closed. All parts of the cases that come in contact with the instrument are lined with felt. All cases are constructed rigidly enough to protect the equipment during shipping. The hanging level should be given special care and, if practical, hand carried.

b. Base and Yoke (including standards). The base and yoke is the largest single part of the T-4, weighing about 70 pounds. The lower part of the assembly (the base) includes the leveling screws and contains the horizontal circle. The U-shaped upper portion (yoke) rotates about the vertical axis of the instrument and contains the horizontal clamp and slow motion assembly. The upper ends of the yoke (standards) are fitted with rollers on which the trunnion axis of the telescope rests.

c. Telescope. The telescope and attached components weigh 40 pounds. The unit usually referred to as the telescope consists of several components. The vertical circle assembly the Horrebow-Talcott levels, the setting circle, and the eyepiece micrometer are all mounted on the telescope axis. The telescope is of the "broken telescope" type. Such telescopes are so named because their eyepieces are mounted in the horizontal axis at right angles to the axis of collimation. A mirror is mounted at the intersection of the two axis to reflect the line of sight from the axis of collimation to the eyepiece axis.

2-3. Instrument Supports

a. The support for the T-4 must be strong enough to carry the weight of the instrument without flexure or strain. The support must not be subject to vibration or sensitive to deflection from the observer's movements. For first order determinations, the instrument should be mounted on a concrete pier. See chapter 5 for concrete pier specifications.

b. Other supports such as an instrument stand or tripod should be used only for lower order observations, or when approval is granted by higher authority. The only tripod suitable for use is the Wild T-4 tripod or its equivalent. The C & GS aluminum stand is probably the best portable stand available. When it is used, all parts must be well seated and the turnbuckles tightened evenly.

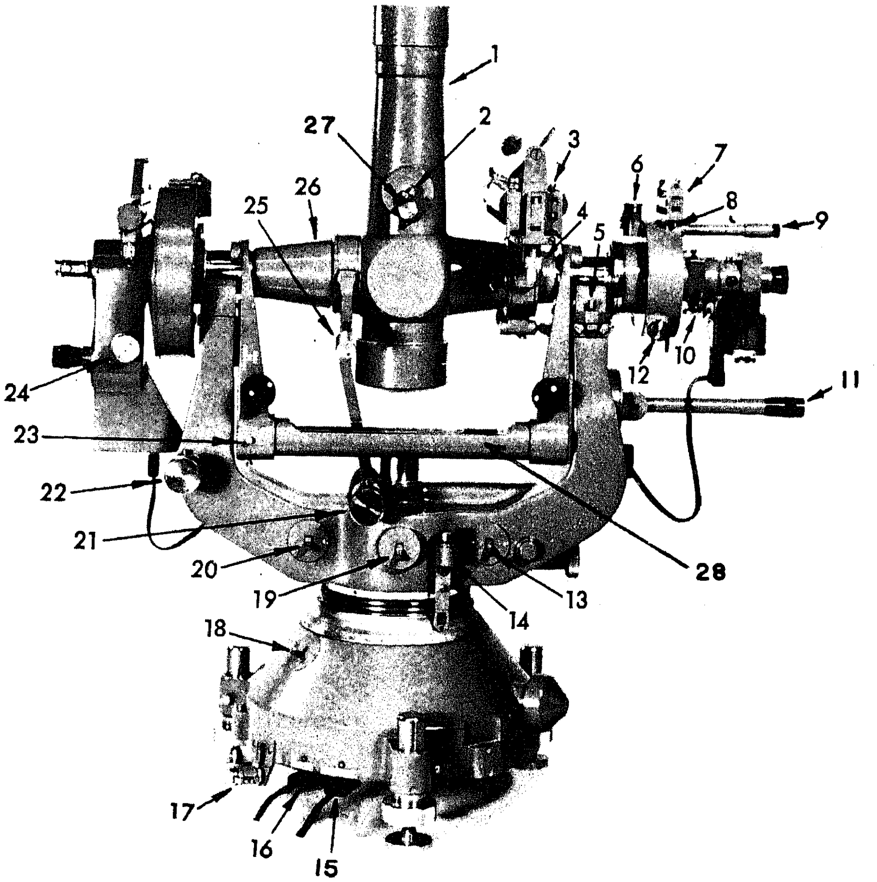
2-4. Erecting the Portable Support

a. The stand or tripod should be set into holes about 2 feet deep that have 6 to 8 inches of hardened plaster of paris in the bottom. In placing the stand it is best if one leg points north or south.

b. After the stand is set on the base it must be centered and leveled (a small carpenter's level provides an excellent check). An inch of plaster of paris should then be poured around the ends of the legs and allowed to dry, so as to anchor the tripod or stand.

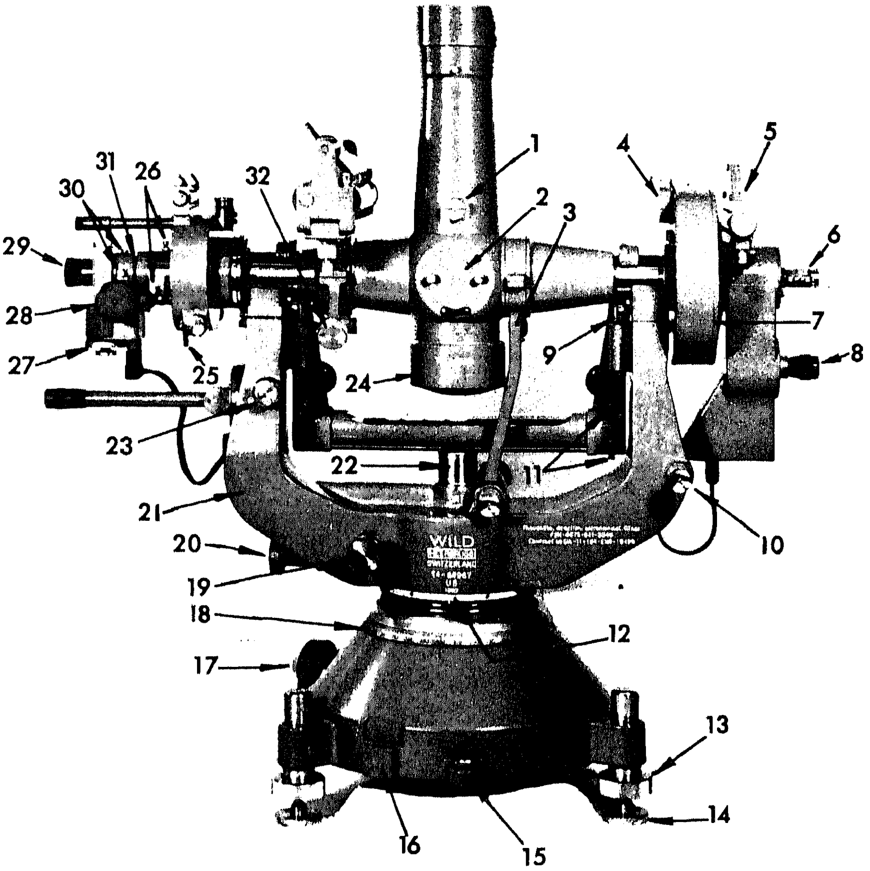
2-5. Plumbing the Instrument

a. If the instrument is to be accurately plumbed over a mark, a large tripod or plumb-bench (approximately 6 feet high) is erected and a plumb bob affixed over the point so that it may be removed and replaced but will remain plumbed over the mark. The instrument support is then placed in position and the instrument base is set atop it. The base is then leveled and shifted atop the support until the point of the plumb bob is exactly



1	Telescope tube
2	Telescope illumination diaphragm
3	Horrebow-Talcott level adjusting screw
4	Horrebow-Talcott level centering screw
5	Horizontal axis adjusting screw
6	Zenith distance setting circle
7	Zenith distance setting circle level
8	Zenith distance setting circle level adjusting screw
9	Zenith distance setting circle eyepiece
10	Eyepiece lock screws
11	Horizontal circle eyepiece
12	Zenith distance setting circle slow motion screw
13	Zenith distance setting circle light switch
14	Horizontal setting circle lamp
15	Chronograph plug receptacle
16	Instrument lighting receptacle
17	Horizontal circle lamp
18	Horizontal circle light switch
19	Telescope light switch
20	Vertical circle light switch
21	Vertical slow motion screw
22	Vertical level collimation screw
23	Hanging level horizontal adjusting screw
24	Vertical circle coincidence
25	Vertical clamp
26	Horizontal axis
27	Telescope lamp
28	Hanging level

Figure 2–1. Wild T-4 Theodolite (circle left).



1 Illumination mirror knob
2 Telescope mirror cover
3 Vertical clamping arm
4 Vertical circle drive cover
5 Vertical circle level
6 Vertical circle lamp
7 Vertical circle
8 Vertical circle eyepiece
9 Horizontal axis roller
10 Vertical circle lock plunger
11 Hanging lever vertical adjustment screws
12 Vertical axis lock ring
13 Leveling screws
14 Leveling screw foot plate
15 Circular level
16 Packing lug
17 Horizontal circle drive cover
18 Horizontal setting circle
19 Horizontal slow motion screw
20 Horizontal clamp
21 Yoke
22 Centering knob
23 Horizontal circle coincidence micrometer
24 Telescope counterweight
25 Zenith distance setting circle release lever
26 Eyepiece lock adjusting screws
27 Eyepiece micrometer scale
28 Eyepiece micrometer hand wheels
29 Telescope eyepiece
30 Eyepiece reticule adjusting screws
31 Infinity stop
32 Horrebow-Talcott level assembly clamp

Figure 2–2. Wild T-4 Theodolite (circle right).

over the center of the cylindrical, German-silver cover mounted in the rotational axis of the yoke. Care must be exercised to maintain a level condition while shifting the base to the centered position. The circular level on the base is adequate for the above plumbing procedure provided the level is in proper adjustment.

b. The base is attached to the instrument support by placing a small amount of plaster of paris under each footplate, pressing the footplate into the plaster, and applying additional plaster over the footplate.

2–6. Assembling the Instrument

a. The base is removed from its case and placed on the instrument support. The orientation of the base should be such that two of the level screws lie in an east-west plane, and preferably such that the battery and chronometer connections are on the side away from the observer's movements to prevent accidental disconnection.

b. The white ring at the junction of the base and yoke assemblies must then be moved, by means of a large adjusting pin, until the red index is over the position marked "messen" ("measure" on newer instruments). This lowers the yoke assembly onto the ball bearings in the base, allowing the yoke to turn freely in azimuth.

NOTE

Before the instrument is replaced in the packing case it is important that the red index be moved to the position "verpacken" ("packed" on newer instruments).The circular level on the base is leveled by means of the footscrews. To increase stability of the instrument, the footscrews should be turned up into their housing as far as possible while still allowing about 2 or 3 turns of screw thread for final leveling.

c. The spring-loaded vertical circle index and vertical slow motion plungers are withdrawn and locked out. The yoke should be placed in such a position that when the observer prepares to place the telescope in the wyes the horizontal circle microscope will be on his right. Before removing the telescope from the packing case the Horrebow-Talcott levels must be clamped to the telescope axis, and the vertical clamping arm for locking the telescope should be clamped in such a way that when the telescope is in the wyes, the telescope will be pointed at the zenith. The bearing surfaces of the telescope and bearings in the wyes must be cleaned of all lubricant before assembly.

d. The horizontal axis of the telescope, to the left of the telescope barrel, is then grasped with the left hand, the setting circle case is grasped with the right hand, and the telescope is placed in the wyes. After the vertical circle and vertical clamping arm are in place the spring-loaded plungers are released. The Horrebow-Talcott levels are then carefully released and set in their stops.

e. The hanging level should be placed on the side of the yoke opposite the horizontal coincidence micrometer knob. The length may be varied by tilting the level to a vertical position and allowing liquid to escape from or enter the chamber. A slight shaking may be necessary for this. The level must be made to hang freely, touching only the telescope axis and the German-silver cover on the yoke.

f. All electrical cords should be attached and the lighting system checked.

2–7. Horizontal Motion System

The horizontal motion system of the T–4 consists of two sections, the horizontal motion controls and the horizontal circle group.

a. Horizontal Motion Controls. The horizontal motion of the T–4 is controlled by the horizontal clamp and the horizontal slow motion screw. These knobs are located on the yoke and their location in respect to the observer is always the same. The clamp is located at the bottom of the standard that supports the eyepiece. The slow motion screw is located just to the right of and at right angles to the clamp. The slow motion screw acts against a spring and all final motion should be made against the spring (clockwise).

b. Horizontal Circle Group. The horizontal circle group consists of the circle and the apparatus necessary to set and read it. The circle is read through a microscope which is attached to the standard that supports the eyepiece end of the horizontal axis. The microscope is hinged and may be folded down against the standard when it is not in use. The horizontal circle rotates about the vertical axis and may be set to desired readings with the horizontal circle drive knob which is located on the base part of the instrument. The knob is protected from accidental movement by a hinged cover which must be kept closed whenever the circle drive is not in use. Note that all horizontal motion control knobs, except the horizontal circle drive, are located so that they may be conveniently operated with the right hand.

2–8. Reading the Horizontal Circle

When reading, the lines of the upper and lower halves of the image are brought into coincidence by use of the horizontal circle coincidence micrometer. The image is marked at the center by use of a single vertical immovable wire that is not used in the reading but as a reference index only. The value of the degree that is to the left of the index line is generally read if one is visible. From this degree value, count the number of subdivisions to the diametrically opposite (180°) degree graduation on the inverted circle image. The value thus determined is then the number of minutes in the angle. The seconds in the angle are read directly from the micrometer (*a*, below). When no upright degree value is visible to the left, the minutes are determined by using the upright degree value to the right of the vertical line. From this degree value, count the subdivisions to the diametrically opposite degree graduation on the inverted circle image. The value thus determined is the minutes to be subtracted from the upright degree value to obtain the degrees and minutes of the angle (*b*, below). The seconds in the angle are read directly from the micrometer. The readings on the horizontal scale increase as the yokes are moved in a clockwise direction.

a. In (a), figure 2-3, 146° is to the left of the index line. Counting the subdivisions from 146° to 326° (diametrically opposite), obtaining 27 subdivisions, which are the number of minutes in the angle. The angle for this illustration is then 146° 27′ 19″.2. In (c), figure 2-3, the angle is determined in the same manner and is 329° 06′ 47″.1.

b. In (b), figure 2-3, 127° is to the right of the index line. Counting the subdivisions from 127° to 307°, obtaining 12 subdivisions. Thus, 12′ are subtracted from 127° and the angle read is then 126° 48′. Adding to this the micrometer reading and the angle is 126° 48′ 03″.9.

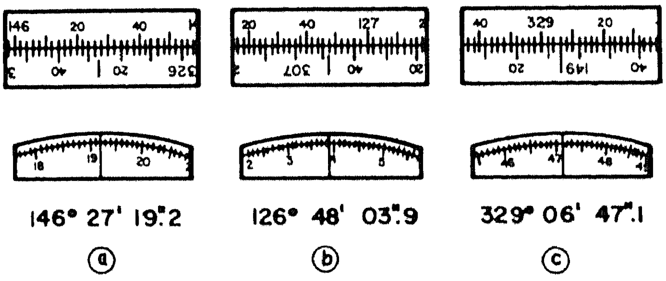


Figure 2-3. Horizontal circle.

2-9. Vertical Motion System

The vertical motion system includes the vertical motion controls and the vertical circle assembly. The vertical motion controls are operated by the observer; however, if zenith distance is to be observed an assistant observer is needed to read the vertical circle. TOPOCOM has developed a modification for the T-4 which replaces the standard vertical circle level vial with one of the Horrebow vials. The Horrebow vial mirror is also mounted on this attachment, allowing the observer to read the inclination of the vertical axis from the eyepiece end of the telescope, thereby eliminating the requirement for the assistant observer. Once the vertical inclination has been so determined relative to the vertical pointing, the observer may then move to the other end of the instrument to read the circle without his weight affecting the observation.

a. Vertical Motion Controls. The vertical motion of the instrument is controlled by two knobs. The vertical clamp is located to the observer's left on a level with the horizontal axis and immediately opposite the telescope tube. The vertical slow motion screw is directly below the clamp on a level with the horizontal part of the yoke. The slow motion screw acts against a spring and all final movement should be made against the spring (clockwise). Note that both controls are placed for convenient operation by the observer with his left hand.

b. Vertical Circle Assembly.

(1) The vertical circle assembly consists of the vertical circle and the vertical circle level. Before reading the vertical circle, the vertical circle level must first be leveled. The level is of the type commonly called a split level, and is leveled by bringing the images of the bubble's ends into coincidence. Since the bubble is extremely sensitive, bringing the bubble ends into perfect coincidence would be time consuming. The vial, therefore, is graduated so that the inclination may be read and a correction computed.

(2) In figure 2-4, the reading on the left minus the reading on the right is twice the level error in graduations ($7.0 - 8.0 = -1.0$ graduation). This value must be multiplied by one-half the value of the level sensitivity in seconds of arc per graduation and applied to the circle reading with the proper algebraic sign to obtain the correct zenith distance.

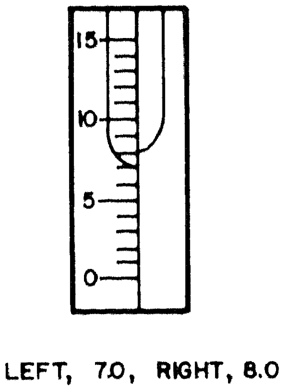


Figure 2-4. Collimation scale.

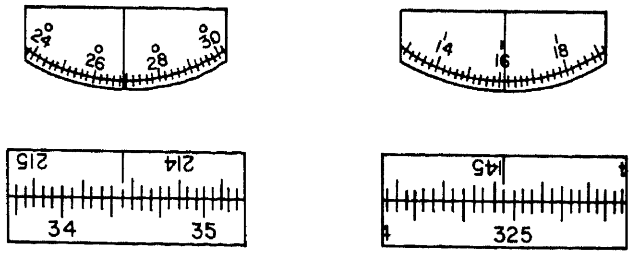
(3) The ends of the bubble should be in coincidence at about the seventh graduation. The bubble length may be adjusted by allowing air to enter or leave the chamber. The bubble should not be

removed from the instrument, but the telescope should be lifted until the vertical circle assembly is clear of the locking plunger, and the assembly turned on the horizontal axis to allow air to enter or leave the chamber.

(4) The vertical circle eyepiece is opposite the eyepiece of the telescope. The coincidence micrometer is located (with respect to the assistant observer) just to the right of and at a right angle to the vertical circle eyepiece. After the vertical circle level has been leveled, the circle graduations are brought into coincidence with the vertical circle coincidence micrometer. Some models of the T–4 have a movable vertical circle. The drive knob, used to set desired readings on the vertical circle, is located on the top-rear of the circle housing, and is protected by a hinged cover to guard against accidental movement.

2–10. Reading the Vertical Circle

a. To read the circle, the vertical circle coincidence micrometer is turned (after the ends of the bubble have been brought into coincidence, or read) until the opposing circle graduations are in coincidence. The angle in degrees is generally read from the lower left. Each graduated interval has a value of 4′ of arc. The intervals between the longer graduations have a value of 20′ of arc. In figure 2–5, 34° is read since it is to the left of the index line. Then, counting the subdivisions from this degree value to the diametrically opposite degree (214°) graduation on the inverted circle image, in this case 12. Multiply the number of subdivisions by 2 to determine the number of *even* minutes (2 × 12 = 24′). The value for the first illustration is then 34° 24′ 26″.9. When no upright degree value is visible to the left of the index line, as in the second illustration, the correct *even* minutes are determined by using the upright number to the right of the index line. From this degree value (325°), count the subdivisions from this value to the diametrically opposite degree (145°) graduation on the inverted circle image, in this case 2. Multiply the subdivisions by 2 and subtract the product from the upright degree value, 325° − (2 × 2) = 324° 56′. With the reading from the micrometer added, the angle for the second illustration is 324° 57′ 16″.1.



34° 24′ 26″.9

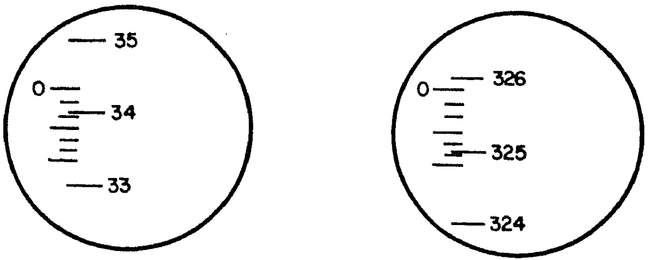
324° 57′ 16″.1

Figure 2–5. Vertical circle.

b. Pointing the telescope toward the zenith results in a circle reading of zero (if the circle is properly set, and collimation error is removed). Readings increase with a counterclockwise motion of the telescope as one faces the vertical circle end of the horizontal axis.

2–11. Zenith Distance Setting Circle

The zenith distance setting circle is directly behind the eyepiece of the telescope. The circle (fig. 2–6) is divided into intervals of 1 degree and is numbered correspondingly. It includes a scale divided into intervals of 10 minutes which may be interpolated to 1 minute. The circle is equipped with a reading microscope and a circle drive for setting the desired readings. The microscope eyepiece is located above the telescope eyepiece and the circle drive is located at the bottom of the circle housing. The circle drive has knobs on both sides of the eyepiece and is equipped with a disengaging lever. The disengaging lever is used to rapidly set the circle to within a degree of the desired setting; then the knobs are used to set the circle to the nearest minute. After the desired reading is set on the circle, the level located at the top of the housing must be leveled. This is done by unclamping the vertical motion clamp and rotating the telescope about its horizontal axis. When the bubble is level the telescope will point to the zenith distance set on the circle, provided the assembly has been properly adjusted.



34° 18′

325° 46′

Figure 2–6. Zenith distance setting circle.

2–12. Horrebow–Talcott Levels

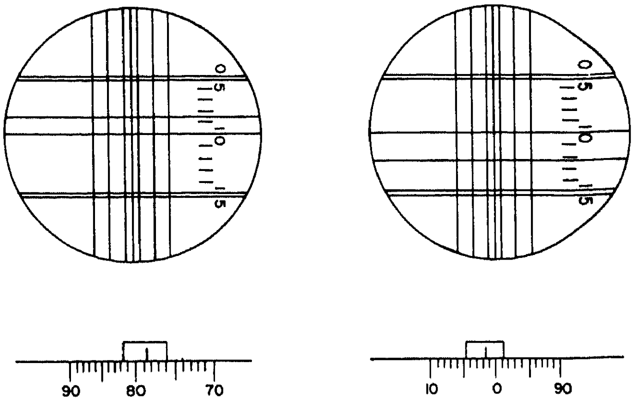
The T–4 is provided with two level vials called Horrebow-Talcott levels. They are located on the horizontal axis between the eyepiece and the telescope tube. When not in use, the level assembly is stabilized by locking it to the standard with the stabilizing pin. When the clamping screw, located to the observer's right on the lower part of the level assembly, is turned firmly in a clockwise direction the level assembly is clamped to the axis, thereby fixing the angle between the level assembly and the telescope axis. The bubbles are then centered with the centering screw, located at the bottom of the level assembly to the observer's left.

2-13. Eyepiece Micrometer

Where the words "crosswire" or "movable wire" are used, it must be understood that these are not actually wires but lines engraved on glass reticles.

a. In order to serve for geodetic measurements as well as astronomic observations, the eyepiece is equipped with both a fixed and a movable reticle. The movable reticle, with its single wire, and the eyepiece lens are fixed with respect to each other. This causes the movable wire to remain in the center of the field of view, sometimes giving the impression that the fixed reticle wires are moving. The movable wire is moved by turning the milled knob located at the bottom of the micrometer or by turning the wheels on the ends of the shaft that is parallel to the movable wire. The shaft has wheels at both ends so that the observer uses both hands to track stars. Just below the eyepiece there is a hinged cover. When this cover is opened the contact drum is exposed. The contact drum consists of an agate disk into which 12 platinum contact strips are set. Ten strips are uniformly distributed over the disk and one of them is marked with an additional strip on each side which serves as the zero contact. This index strip is used to count the complete turns of the micrometer screw and to facilitate the identification of the intermediate contacts. A contact point mounted on the drum completes an electric circuit when it touches a contact strip. The contact drum must be kept clean of all foreign matter to avoid erroneous readings due to interrupted or late contacts.

b. The crosswires of the fixed reticle, which are parallel to the movable wire, may be used for the measurement of small angles. Because the eyepiece can be rotated on the horizontal axis, the micrometer can be used for measuring small angles in both vertical and horizontal planes. The marks between the 05 and the 15 wires indicate the number of turns of the micrometer. The position of the movable wire may be expressed in terms of turns of the micrometer, 05 to 15. The portion of a turn can be determined by reading the micrometer scale located at the bottom of the micrometer. The scale is graduated into 100 divisions. Every tenth line is numbered, 0 through 90, and every fifth line is elongated. As the wire moves from one of the wires to the next higher numbered one, the readings on the scale increase and indicate the portion of that turn through which the wire has moved. The scale reading may be estimated to the 0.1 of a division, or 1,000th of a turn (fig. 2-7).



8 TURNS, 78.7 GRADS OR
8.787 TURNS

12 TURNS, 01.4 GRADS OR
12.014 TURNS

Figure 2-7. Reading the eyepiece micrometer.

2-14. Instrument Lighting System

a. The power required for the lighting is 4.5 or 12 volts, depending on the bulbs being used. The power cord is connected to the instrument at the male plug at the bottom of the base. There are four lights on the instrument (newer models have a fifth light for the horizontal setting circle on the outside of the base cone). The horizontal circle light is controlled by the switch located on the base of the instrument. The three switches on the yoke, starting at the eyepiece end, are for the setting circle, the telescope, and the vertical circle. The intensity of the telescope light can be controlled by three different methods: by the rheostat at the power source, by a disk with eight different size holes at the telescope light, and by the reflecting mirror in the telescope.

b. For daylight observations the vertical and horizontal circle lights can be removed and replaced by mirrors. The setting circle light can be removed to permit enough light through the opening to illuminate the circle.

2-15. Leveling the Vertical Axis

a. The horizontal axis of the telescope with the hanging level is set parallel to the line joining two footscrews and the settled position of the bubble is read. Although a reading at one end of the bubble is adequate, the mean center may be determined by summing the end readings and dividing by two.

The instrument is then turned 180° and the
is read in the same way as before. The bub-
s then set, by means of the two footscrews, to
arithmetic mean of the readings for the two
ions.

The instrument is then turned 90° and the
set, by means of the third footscrew, to the
mean value. Turning the instrument 180°
reading at the same end once again, the arith-
c mean of the two readings is set on the level.
process is continued until the same reading
in one graduation is obtained in any quadrant.
vertical axis is then pointing at the astro-
c zenith.

. Leveling the Horizontal Axis

After the vertical axis has been leveled to
in one graduation the horizontal axis must be
perpendicular to the vertical axis. The hori-
l motion is locked and the level read. The
ing level is then removed and placed on the
site side of the horizontal axis and read. The
metic mean is set on the level by turning the
capstan head screw at the top of the stand-
n the eyepiece side.

This process is repeated until the variation
greater than two graduations. The hanging
is finally replaced on the side of the yoke
ite the horizontal coincidence micrometer.

. Adjusting the Hanging Level

Wind. The hanging level is used to measure
ation of the vertical axis of the instrument.
rtical planes through the horizontal axis
nion axis) and the hanging level axis of the
ment are *not* parallel to each other, the in-
ent is said to have wind (pronounced
d"), and the hanging level *will not* indicate
ue inclination of the vertical axis. Prior to
bservation with the instrument, the hanging
must be checked for the presence of wind
djusted as necessary (fig. 2–8).

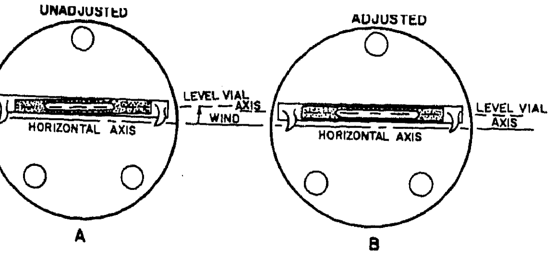


Figure 2–8. Effects of error of wind.

) The level is checked for wind by attach-
string to the middle of the bar parallel to the level vial and very carefully pulling the level 3 or 4 inches away from the "rest" position. If there is no wind, the *bubble will remain stationary.* If there is wind, the bubble will move toward the end of the vial that is displaced in the direction of the pull.

(2) The adjustment for wind is made by alining the level vial horizontally in its housing with the horizontally opposed capstan screws located at the high numbered end of the level housing. The level is in adjustment if the bubble movement is three divisions or less when the level is pulled 3 or 4 inches away from the "rest" position.

(3) All adjustments of the level must be made very carefully. One screw must be loosened before the opposing screw is tightened. Overtightening the adjusting screw may cause undue strains that have detrimental effects on the adjustment.

b. Centering the Bubble. After all other adjustments have been made the bubble is centered (mean bubble center is 50) by turning the vertically opposed capstan screws located at the high numbered end of the level vial.

2–18. Adjusting the Instrument

a. In all testing which requires a well defined distant object but where none is available, any other optical survey instrument may serve as a collimator. The instrument serving as the collimator is set up at a distance of 5 to 10 meters and leveled. The instruments are then pointed at one another and by careful manipulation the two instruments can be made to point along the same line; thus, by looking through one instrument the observer will be able to see through the other. Both instruments must be focused at infinity. The eyepiece is then removed from the instrument serving as the collimator and a frosted flashlight bulb, connected through a rheostat to a power supply, is inserted in its place. The observer at the T–4 should now be able to see the crosswires of the collimator; observations on these are then used to adjust the T–4.

b. All adjustments of the eyepiece should be done in infinity focus if possible.

2–19. Verticality of the Crosswires

With the eyepiece locked in position, a sharp, well defined object is observed and the telescope is moved vertically. If the object tracks the wire through the field of view the wire is vertical; if the object moves off the vertical wire an adjustment must be made with the capstan screw opposite the locking screw on the eyepiece. Verticality must be ascertained in both eyepiece positions.

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2–20. Centering the Crosswires

When the eyepiece is rotated it is necessary that the center of the crosswires remain in the same relative position (fig. 2–9). This may be accomplished by placing the intersection of the crosswires on a sharp well defined target and rotating the eyepiece 90°. If the target moves off the intersection, the crosswires will describe a quadrant of a circle whose center will lie in the physical center of rotation of the telescope axis. By means of the two sets of opposed capstan screws immediately behind the micrometer box, the intersection of the reticle crosswires should be moved to the center of the quadrant described. Repeat the test and adjustment until the intersection of crosswires remains on the target when the micrometer is rotated.

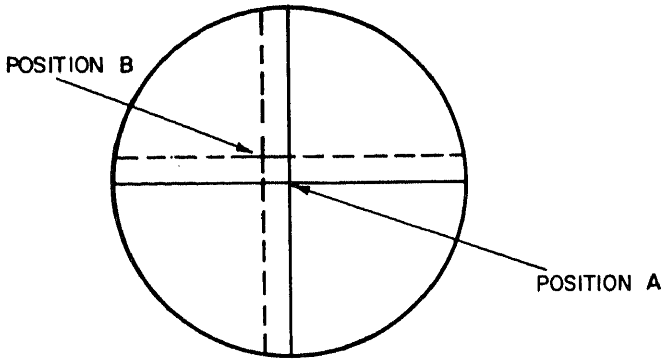


Figure 2–9. Crosswires not centered.

2–21. Adjustment of Horizontal Collimation

This adjustment is made as with any theodolite type instrument except that instead of the reticle being moved to remove the error the adjustment is made by moving the mirror located where the telescope barrel joins the horizontal axis of the telescope. The mirror is exposed by removing the plate which is held in place by two knurled screws. This exposes two opposing capstan screws acting upon the mirror. One man adjusts the mirror with adjusting pins as another man, looking through the telescope at the target, directs. When finished, the screws must be tight but not binding; the collimation error should be less than 3 seconds of arc.

2–22. Adjustment of Vertical Collimation

a. Adjustment of the vertical collimation is made in the same way as that of the T–2 theodolite. The zenith distance of a well defined object is measured with the instrument in the direct and reverse positions. Half of the difference of the sum of the direct and reverse readings from 360° is determined. This value is added to or subtracted from the circle reading, as appropriate, and the resulting value is then set on the vertical circle with the coincidence micrometer. The telescope crosswires must remain on the target throughout this operation. The vertical circle is brought into coincidence with the level collimation screw and then the ends of the vertical circle level bubble are brought into coincidence by use of the capstan screws acting on the level holder. The collimation error should be less than 2 seconds of arc.

b. When the instrument has a vertical circle that may be set with a drive knob, the correction may be so large that the proper value cannot be set with the coincidence micrometer. In this case the vertical circle drive is used to set the degrees and minutes correctly, with a very close coincidence, and then the coincidence micrometer is used for the final setting. The ends of the level bubble are then brought into coincidence as before.

2–23. Zenith Distance Setting Circle Level

When the telescope is pointing to the zenith and the zenith distance setting circle is set to 0°, the level bubble should be centered. If not, the level on the setting circle may be adjusted as follows: using the vertical circle (properly adjusted with minimum collimation), set a zenith distance of 0° 00′ 00″ and level the vertical circle bubble closely (it need not be in exact coincidence because the setting circle can be interpolated only to the nearest 01′ of arc). The setting circle is set at the zenith distance of 0° and by use of the capstan screws acting on the setting circle level, the bubble is brought to center.

2–24. Adjustment of the Eyepiece Micrometer Drum

Exact adjustment of the micrometer drum is not necessary except when the Horrebow-Talcott method is used for latitude observations. When this method is used the following two adjustments of the micrometer drum are made.

a. When the movable wire is in coincidence with the center (10) wire of the fixed reticle the micrometer should read "0" and the platinum tip should be in the middle of the "0" contact strip. In setting the micrometer at "0" when the movable wire is in coincidence with the "10" wire, the small pin-faced spanner wrench is hooked in the holes of the shaft of the micrometer scale. The knurled nut under the scale is held with the fingers while the wrench is turned counterclockwise. After the micrometer scale is moved to "0" the nut is tightened and the adjustment then checked.

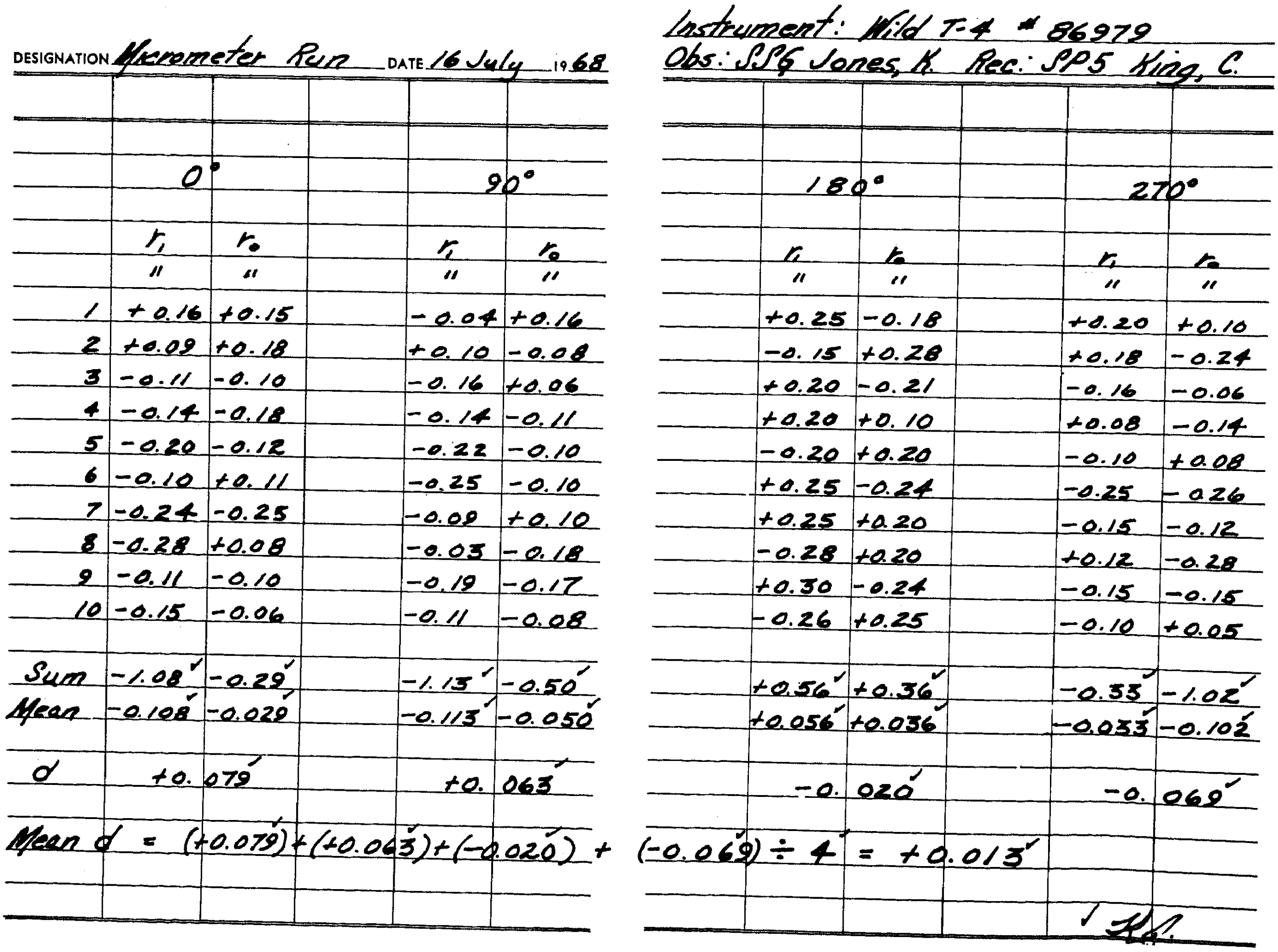
b. In placing the center of the "0" contact of the drum onto the platinum tip when the movable wire is on the "10" wire, the cover over the drum is removed by taking out the screws holding the cover. With the pin-faced spanner the round nut holding the micrometer scale is removed. The knob, micrometer scale, and the cover are then removed. The setscrew holding the contact drum must then be loosened. With the movable wire on the "10" the drum is turned by hand until the platinum tip is in the center of the "0" contact. The setscrew is then tightened. When the adjustment is satisfactory, the cover, micrometer scale, and nut are replaced. The micrometer is set to "0" when the movable wire is on "10" and the round nut is then tightened with the spanner.

2-25. Micrometer Run

The term micrometer run means the difference between an interval measured by the circle graduations and the same interval measured with the coincidence micrometer. In the factory the measuring interval of the micrometer is adjusted with greatest care and accuracy to the size of the image of a circle division. This adjustment can be regarded as very stable from the constructional viewpoint. This adjustment cannot under any circumstances be done in the field. As we are dealing with observations of the highest accuracy, we must not assume any adjustment as free of errors and we must check the adjustment of the micrometer of the horizontal and of the vertical circle. It is especially important that the micrometer run be determined before the vertical circle is used for the calibration of level vials and Sterneck latitude observations.

a. If the run exceeds ± 1" per 1' of the micrometer the observation for run must be made a part of the field record. As this adjustment cannot be made in the field, if the run is excessive and the instrument must be used, a correction factor must be determined.

b. In order to determine the measuring interval of the coincidence micrometer of the horizontal



DESIGNATION Micrometer Run DATE 16 July 1968

Instrument: Wild T-4 # 86979

Obs: SSG Jones, K. Rec: SP5 King, C.

	0°		90°		180°		270°	
	r_1	r_0	r_1	r_0	r_1	r_0	r_1	r_0
	"	"	"	"	"	"	"	"
1	+0.16	+0.15	-0.04	+0.16	+0.25	-0.18	+0.20	+0.10
2	+0.09	+0.18	+0.10	-0.08	-0.15	+0.28	+0.18	-0.24
3	-0.11	-0.10	-0.16	+0.06	+0.20	-0.21	-0.16	-0.06
4	-0.14	-0.18	-0.14	-0.11	+0.20	+0.10	+0.08	-0.14
5	-0.20	-0.12	-0.22	-0.10	-0.20	+0.20	-0.10	+0.08
6	-0.10	+0.11	-0.25	-0.10	+0.25	-0.24	-0.25	-0.26
7	-0.24	-0.25	-0.09	+0.10	+0.25	+0.20	-0.15	-0.12
8	-0.28	+0.08	-0.03	-0.18	-0.28	+0.20	+0.12	-0.28
9	-0.11	-0.10	-0.19	-0.17	+0.30	-0.24	-0.15	-0.15
10	-0.15	-0.06	-0.11	-0.08	-0.26	+0.25	-0.10	+0.05
Sum	-1.08 ✓	-0.29 ✓	-1.13 ✓	-0.50 ✓	+0.56 ✓	+0.36 ✓	-0.33 ✓	-1.02 ✓
Mean	-0.108 ✓	-0.029 ✓	-0.113 ✓	-0.050 ✓	+0.056 ✓	+0.036 ✓	-0.033 ✓	-0.102 ✓
d	+0.079 ✓		+0.063 ✓		-0.020 ✓		-0.069 ✓	

Mean d = (+0.079) + (+0.063) + (-0.020) + (-0.069) ÷ 4 = +0.013 ✓

✓

Figure 2-10. Micrometer run determination.

circle, the coincidence micrometer is set to 00″ and a circle graduation is brought into coincidence with the slow motion screw. Several coincidences are made with the micrometer and the mentally computed mean, which should be very close to 00″, is recorded. The micrometer is then turned to the other end of the scale (60″ for horizontal or 1′ 60″ for vertical). This will bring the next adjacent circle graduation closely into coincidence. Each of these marks should be pointed and read 10 times. This measurement is to be carried out for several circle graduations and afterwards a mean determined (fig. 2–10).

c. The recordings of the readings should follow the format shown in figure 2–10.

(1) Readings on the left of the micrometer mark 0″ (60″) are negative.

(2) Readings on the right of the micrometer mark 0″ (60″) are positive.

(3) By denoting the readings at 0″ by r_1, and those at 60″ by r_o, then the difference (d) is determined by:

$r_o - r_1 = d$, where d is the length of a circle graduation in units of the reading micrometer.

(4) If d is greater than 0.000, the micrometer interval is less than the circle graduation.

(5) If d is less than 0.000, the micrometer interval is greater than the circle graduation.

(6) The algebraic sum and the mean of each column are determined, then d is determined by $r_o - r_1$ for each circle graduation.

(7) The algebraic sum of all of the d determinations is found. This sum is then divided by the total number of determinations and a mean d is determined. The mean d should be less than 1″ if the instrument is in good adjustment. If the mean d is greater than 1″, then all observation readings should be corrected by prorating the amount of d before any other computations are started.

CHAPTER 3

INSTRUMENT CONSTANTS

Section I. Level Vial Constants

3–1. General

Observations conducted with the T–4 theodolite are of such precision that errors which may be ignored in observations of less precision must be determined. All level vials of the T–4 must be calibrated periodically to determine their values for the computation of corrections to be applied to the observed data. The various methods used for calibration of the level vials are discussed in this section.

a. Errors of dislevelment are corrected by applying the sensitivity of the level vial, multiplied by the dislevelment, to the observations. Level vial sensitivity varies over a period of time and under various conditions. Theoretically, the level trier method of determining level vial sensitivity is the most precise method. However, the conditions in the field are seldom the same as conditions prevailing when the level trier was used, and the value so determined is questionable. Field methods, described herein, yield a more reliable value of the sensitivity, as they are determined under the same conditions as are the actual observations for position and azimuth.

b. Sensitivity of the level vials varies according to the temperature, level vial age, bubble length, stresses on the vial, and other factors. When observing, the bubble length should be kept within one or two divisions of the length used in calibration. If the ambient temperature varies greatly from the temperature which existed during calibration (10° to 20°F.), the vials should be recalibrated. Once a vial has been calibrated it should not be removed from its holder unless a recalibration is performed. Additionally, after calibration, the vertical circle level should not be removed from the instrument nor the Horrebow-Talcott levels from their frame. Sensitive level vials have slow settling bubbles, which makes it essential to wait until the bubble comes to a complete rest before making readings. The calibrations are conducted in sets and in order to obtain accurate results it is imperative that all movement near the instrument be kept to a minimum during the observation of the individual sets.

c. It is imperative that the temperature observed during level vial calibration be recorded as part of the calibration data.

d. The order in which the level vials should be calibrated is—

(1) Vertical circle level vial
(2) Hanging level vial
(3) Horrebow-Talcott level vials

3–2. Wisconsin Method

This level calibration method provides a means of determining level sensitivity in the field without removing the vials from the instrument. It can be used to calibrate the T–4 hanging level and the plate level of other survey instruments.

a. Theory.

(1) The Wisconsin method is more involved than the level trier method. The instrument is carefully leveled and the level vial is placed in a line parallel to two footscrews. The third footscrew is then moved by a measured amount (i), and the instrument turned in azimuth by a measured amount (AZ_2) (fig. 3–1).

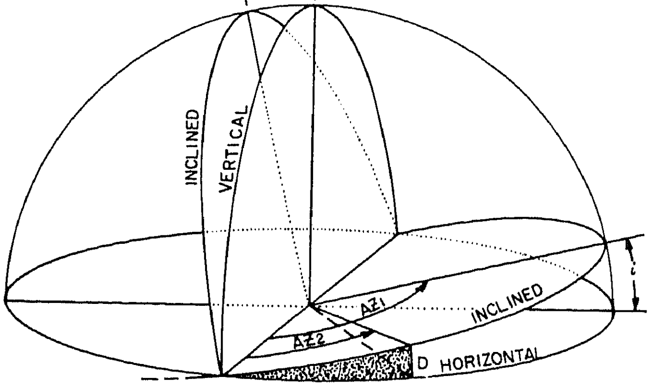
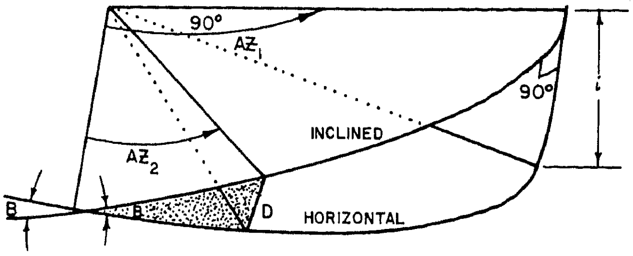


Figure 3–1. Theory of the Wisconsin method.

This gives sufficient information to compute, by the solution of similar right spherical triangles, the amount that the vial end is elevated or depressed (fig. 3-2). The figure shows the development of the formula for computing the amount of depression of the bubble end (D).



$$\text{Cot } B = \frac{\text{Sin } AZ_1}{\text{Tan } i} \qquad \text{Sin } AZ_1 = \text{Sin } 90° = 1$$

$$\text{Cot } B = \frac{\text{Sin } AZ_2}{\text{Tan } D} \qquad \frac{1}{\text{Tan } i} = \frac{\text{Sin } AZ_2}{\text{Tan } D}$$

$$\frac{\text{Sin } AZ_1}{\text{Tan } i} = \frac{\text{Sin } AZ_2}{\text{Tan } D} \qquad \text{Tan } D = \text{Sin } AZ_2 \text{ Tan } i$$

Figure 3-2. Mathematics of the Wisconsin method.

(2) For small angles the tangent and the sine are approximately the same, therefore, dividing both sides of the equation by the sine of 1″, D = AZ tan i. The sensitivity of the level vial per division then is (D/bubble movement). For example, a single reading of i, AZ, and bubble movement, converted to level sensitivity is—

Inclination (i) = 01° 00′ 03″.7
Tan i = .01747300
Bubble movement = 1.75 divisions
Change of azimuth = 2′

$$\frac{(2)\,(60)\,(0.01747300)}{1.75} = 1.198 \text{ seconds per division}$$

b. Procedure.

(1) *Alining the level vial.* The instrument must be leveled carefully and the bubble of the level vial to be calibrated centered. The vertical plane through the barrel of the telescope is then alined approximately over one footscrew. This footscrew is then turned (raising or lowering the instrument) and the bubble is observed for motion. If the bubble moves, the telescope is turned in azimuth until the bubble is again centered. urning the footscrew continues and the azimuth f the telescope is corrected until no bubble movement occurs. When raising or lowering the footcrew causes no movement of the bubble, the level vial is alined parallel to the other two footscrews. The horizontal circle of the instrument is now set to read 00° 00′ 00″, using the horizontal circle drive screw. When determining the inclination (i) during the calibration the horizontal reading must always be checked to insure that it is 00° 00′ 00″.

(2) *Measuring inclination (i).*

(*a*) *For the T-4.* The instrument is then releveled within one division. With the telescope pointing at the zenith and locked in position, the instrument is turned in azimuth until the horizontal circle reads exactly 00° 00′ 00″. The vertical circle is brought into coincidence several times and the mean reading is recorded. The left and right ends of the vertical circle level are read and recorded to the nearest 0.1 of a division. The footscrew, over which the telescope was alined, is turned to either raise or lower the telescope by approximately 1°. *The instrument remains in this inclined position throughout the calibration of that group.* This inclines the vertical axis of the instrument in the vertical plane through the footscrew and the center of the instrument. The vertical circle and the vertical circle level are again read and recorded, as above. The inclination (i) is determined from the difference of the zenith distances of the vertical axis in the vertical position and in the inclined position. The vial being calibrated should be checked for bubble movement during the determination of inclination. If it has moved, the alinement procedure must be repeated.

(*b*) *For the T-3.* The procedure is the same as for the T-4 except that the telescope is set to 90° (horizontal) rather than pointed at the zenith. The instrument is then inclined approximately 2° with the footscrew over which the telescope is alined. In order to bring the vertical circle into coincidence it will be necessary to place a suitable shim such as a small coin between the vertical level collimation screw and the vertical level vial actuating arm. NOTE: Since the vertical circle of the T-3 is half numbered, the vertical circle will read 91° 00′ 00″ when the inclination is 2°. The vertical angle of a single reading with the T-3 is equal to twice the difference between the circle reading and 90°.

(3) *Observations.* After the readings for the determination of inclination are completed, the instrument is moved in azimuth until one end of the bubble is near the end of the vial. This will normally require moving the instrument about 14 minutes. For the first bubble reading the azimuth should read an even minute of arc, that is: 359° 46′ or 00° 14′. After the bubble has settled, the left and right ends of the bubble are read to the

Column 1. Group, set, and position of the telescope (level or inclined).

Column 2, 3, and 4. Vertical circle readings.

Column 5 and 6. Vertical level vial readings.

Column 7 and 8. Vertical level vial differences, (L–R) in divisions and arc, i.e., d/2 (L–R).

Column 9, 10, and 11. Corrected vertical circle readings.

(2) *Observations.* The record for the level value determination is kept on DA Form 5-72 as follows (fig. 3-4):

Column 1. The azimuths of the instrument. The numbers represent the azimuths in minutes of arc either less than 360° (minus azimuths) or more than 00° (plus azimuths). If the horizontal circle reads 359° 46′, the azimuth would be −14′, and if circle reading was 00° 14′, the azimuth would be +14′ (see *d*(3) below).

Column 2 and 3. Reading of the level vial, left and right ends, as the observer faces the level vial.

Column 4 and 5. Changes in the readings of the left and right ends of the level vial. If the adjacent values differ by more than 0.2 division, the bubble ends have been incorrectly read.

Column 6. The mean of columns 4 and 5.

Column 7. The mean center of the bubble for each reading.

Column 8 and 9. The correction and adjusted center are computed values entered after the observation is completed.

OBS: SSG JONES REC: SP5 MARTIN				TEMP:	61.4°F	DETM	OF LEVEL	VALUE	"WISCONSIN	METHOD"	
GROUP	1 - A		DATE: 6	MAY (PM)	1968	VIAL #	735		INST:	T4 #	86979
MICROMETER READING (X)	BUBBLE LEFT	READINGS RIGHT	DIFFERENCES LEFT	RIGHT	MEAN DIFF	BUBBLE CENTER	CORR	ADJUSTED CENTER (Y)	REMARKS		
+20 17′	09.2	56.0				32.60	− 0.00	32.60	i =	01° 00′	00.″2
+18 15′	11.1	58.0	1.9	2.0	1.95	34.55	0.05	34.50	tan i =	0.0174	5603
+16 13′	13.2	60.0	2.1	2.0	2.05	36.60	0.11	36.49			
+14 11′	15.2	62.1	2.0	2.1	2.05	38.65	0.16	38.49	[xx] =	1938	
+12 9′	17.1	64.0	1.9	1.9	1.90	40.55	0.21	40.34	[xY] =	−2111.18	
+10 7′	19.3	66.0	2.2	2.0	2.10	42.65	0.26	42.39		[xx](Cotan i)	
+8 5′	21.7	68.4	2.4	2.4	2.40	45.05	0.32	44.73	d =	[xY]	
+6 3′	23.8	70.5	2.1	2.1	2.10	47.15	0.37	46.78			
+4 1′	25.9	72.7	2.1	2.2	2.15	49.30	0.42	48.88			
+2 −1′	28.2	74.8	2.3	2.1	2.20	51.50	0.48	51.02	d =	0.9614	
0 −3′	30.6	77.2	2.4	2.4	2.40	53.90	0.53	53.37			
−2 −5′	32.8	79.4	2.2	2.2	2.20	56.10	0.58	55.52			
−4 −7′	34.9	81.4	2.1	2.0	2.05	58.15	0.63	57.52			
−6 −9′	37.0	83.5	2.1	2.1	2.10	60.25	0.69	59.56			
−8 −11′	39.9	86.3	2.9	2.8	2.85	63.10	0.74	62.36			
−10 −13′	42.6	89.1	2.7	2.8	2.75	65.85	0.79	65.06			
−12 −15′	45.0	91.7	2.4	2.6	2.50	68.35	0.84	67.51			
−14 −17′	47.0	93.8	2.0	2.1	2.05	70.40	0.90	69.50			
+20	10.3	56.8	+1.1	+0.8	+0.95	33.55	0.95	32.60			gcg
						CORR PER	OBS =	−0.95 / 18	= −0.05278		

Figure 3-4. Observation notekeeping.

d. Computations. The computation of the level value (d) is accomplished on the recording form.

(1) *Adjustment of mean bubble* (y). The first step in the computation of d is the adjustment of the mean bubble readings y for drift of the vertical axis. The amount of the drift is determined by subtracting the mean bubble reading of the first azimuth setting from the mean bubble reading of the closure check. Assuming that the drift of the vertical axis is proportional to the number of observations, each bubble reading will take the same correction. This correction is equal to the amount of drift divided by the number of observations minus one (n–1) where the closure observation is considered as one of the observations. The correction is now applied accumulatively to the mean bubble readings with a sign opposite to that of the drift.

(2) *Computation of level value* (d). The adjusted mean bubble readings are used to compute d from:

$$d = \frac{[xx]\ (60 \tan i)}{[xy]}$$

Where:

x = azimuth reading in minutes of arc (column 1).
y = adjusted mean level readings (column 9).

(3) x *values.* For the above formula, the algebraic sum of the x values must equal zero. If symmetric observations have not been made, then the azimuth readings must be changed to make the summation of x equal zero. For example, in figure 3–4, the readings started with an azimuth of $+20$ and ended with an azimuth of -14; the first x value will be $(20 + 14)/2 = 17$. The successive x values are $+15, +13, +11, +9, +7, +5, +3, +1, -1, -3, -5, \ldots\ldots -17$.

e. Summary of Results and Probable Error. The results of the observations are summarized on the recording form (fig. 3–5):

(1) The probable error of the mean is computed from —

$$e_r = \pm 0.6745 \sqrt{\frac{[vv]}{n(n-1)}}$$

Where:

e_r = probable error of the result
v = residual
n = number of groups

(2) The probable error of a single group is computed from—

$$e_g = \pm 0.6745 \sqrt{\frac{[vv]}{n-1}}$$

or

$$e_g = e_r \sqrt{n}$$

f. Allowable Errors and Rejection Limits.

(1) e_r must not exceed ± 0.″01 per 1 second of the level value. Thus, the allowable e_r for a hanging level of a T–4 will be about 0.″01.

(2) The allowable probable error of a single group is computed as follows:

Allowable $e_g = \pm 0''.01\ (d)\ \sqrt{n}$

d = level value per division in seconds of arc
n = number of groups

(3) Residuals (v) shall not exceed two times the allowable e_g. Any group having an excessive residual shall be rejected and re-observed.

(4) If the result of dividing the largest residual by $(n + 1)$ is greater than the allowable e_r, additional observations will be made.

3–3. Vertical Circle Method

This method may be used with any instrument having a graduated vertical circle level vial. As with the Wisconsin method, it affords level sensitivity determination in the field under observing conditions without removing the vial from the instrument.

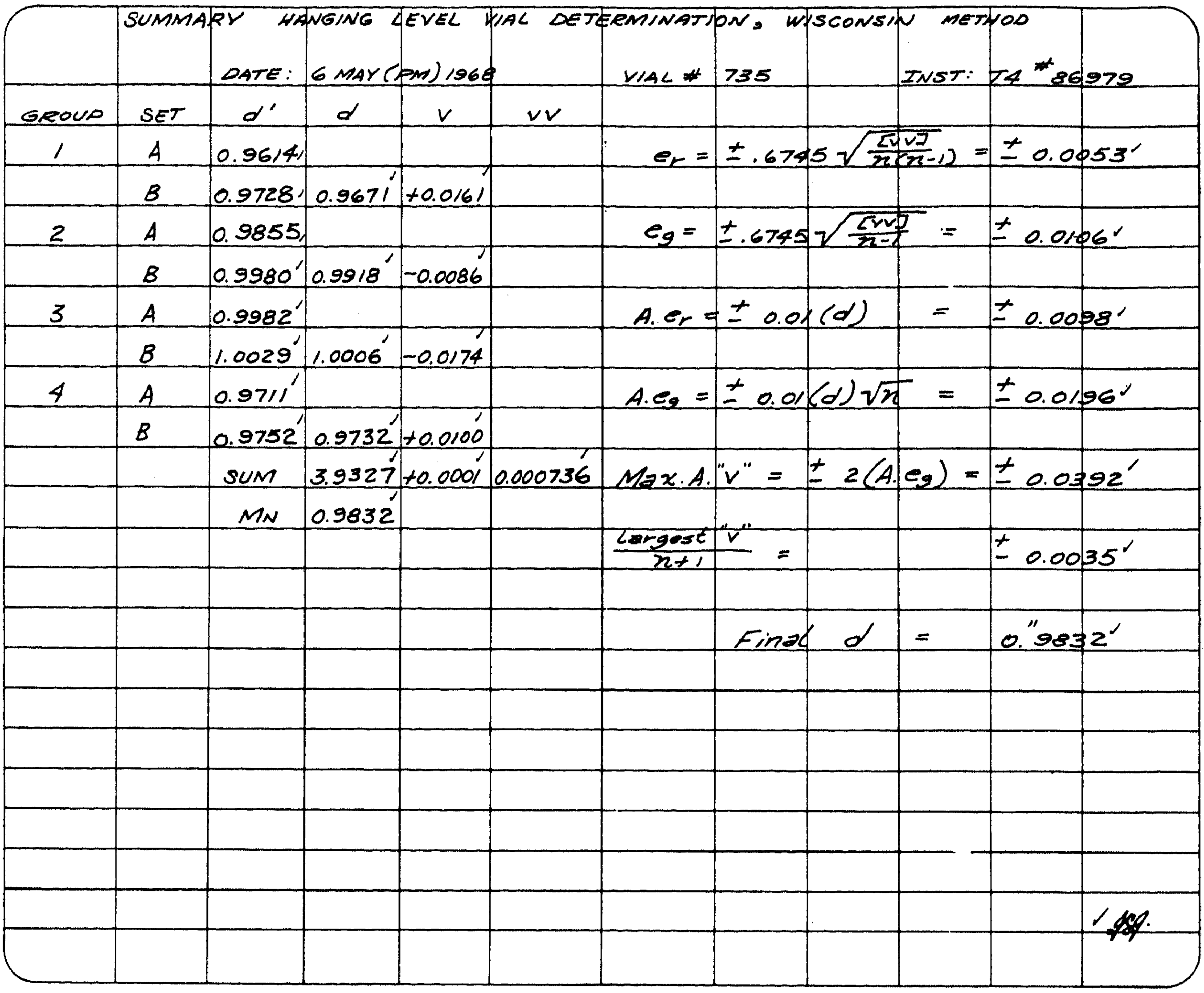
a. Theory. This method of level vial calibration utilizes the vertical circle to determine inclination of the vial. Any run in the vertical circle micrometer will be introduced into the calibration. See paragraph 2–25 for determination of micrometer run.

b. Procedure.

(1) The length of the bubble is first adjusted to about one-half of the length of the vial (for T–4, the ends should be in coincidence at the seventh graduation). The length of the bubble may be adjusted by lifting the telescope off the standards and rotating the vertical circle assembly so that liquid can enter or leave the chamber. The telescope is replaced on the standards and the telescope locked in the approximate zenith position.

(2) The vertical axis of the instrument is carefully leveled. Then the vertical circle bubble is moved close to one end of the vial by means of the vertical level collimation screw. It is of utmost importance that the instrument support be very stable in order to eliminate irregular drift of the vertical axis of the instrument.

(3) After the bubble has settled the ends of the bubble are read and recorded. The vertical circle is brought into coincidence, read, and recorded. Although only one reading for the seconds of the vertical circle is entered on the record, several coincidences should be made and a mentally computed mean of these coincidences entered in



SUMMARY HANGING LEVEL VIAL DETERMINATION, WISCONSIN METHOD

DATE: 6 MAY (PM) 1968 VIAL # 735 INST: T4 # 86979

GROUP	SET	d'	d	v	vv	
1	A	0.9614				$e_r = \pm .6745\sqrt{\frac{[vv]}{n(n-1)}} = \pm 0.0053'$
	B	0.9728	0.9671	+0.0161		
2	A	0.9855				$e_g = \pm .6745\sqrt{\frac{[vv]}{n-1}} = \pm 0.0106'$
	B	0.9980	0.9918	−0.0086		
3	A	0.9982				$A.e_r = \pm 0.01(d) = \pm 0.0098'$
	B	1.0029	1.0006	−0.0174		
4	A	0.9711				$A.e_g = \pm 0.01(d)\sqrt{n} = \pm 0.0196'$
	B	0.9752	0.9732	+0.0100		
		SUM	3.9327	+0.0001	0.000736	Max. A. "v" = $\pm 2(A.e_g) = \pm 0.0392'$
		MN	0.9832			
						$\frac{\text{Largest "v"}}{n+1} = \pm 0.0035'$
						Final d = 0."9832'

Figure 3-5. Wisconsin method summary.

the record. The bubble is then moved approximately two divisions by turning the level collimation screw. The vertical circle and bubble ends are read and recorded again. This operation is continued until the opposite end of the level vial is reached. Uniform bubble movement can be achieved by setting a reading on the vertical circle that corresponds to about two divisions of the vial. Assuming a level value of 2.5 seconds of arc per division, the circle reading should be changed about 4 seconds of arc to move the ends of the bubble approximately two divisions. The direction of the bubble is then reversed and the process continued until the bubble returns to the starting position. This completes one set of observations. At least four sets must be observed for a completed level determination.

c. Notekeeping. The recording is done on DA Form 5-72 as follows (fig. 3-6):

Column 1.	Vertical circle reading (x). There is no need to record the minutes of the reading. If the circle reading increases to the next higher minute, 60 seconds are added to all circle readings taken after the minute mark has passed. If the reading decreases to the next lower minute, 60 seconds are added to all readings taken before the minute mark was passed.
Column 2 and 3.	Vertical level bubble readings, left and right ends.
Column 4 and 5.	Changes in the readings of the left and right ends of the level

vial. If the adjacent values differ by more than 0.2 division the bubble ends have been incorrectly read.

Column 6. The difference between columns 4 and 5, in the sense left minus right.

Column 7. The difference between columns 2 and 3, in the sense left minus right. This value y is equal to twice the inclination of the vial in terms of divisions.

d. Computations. The computations are performed on the recording form (fig. 3-6).

(1) *Office computations.* The first step in the computations is the determination of the individual values of y. The value y is equal to two times the inclination of the level and is determined by subtracting the right end bubble readings from the left end bubble readings. It may also be computed by adding successively the values in column 6 to the first value in column 7. The values of y should be computed in both manners. This will give a check on all work prior to the solution of the formula for d. The level value is determined from—

$$\frac{d}{2} = \frac{[xx] - \frac{[x]^2}{n}}{[xy] - \frac{[x]\,[y]}{n}}$$

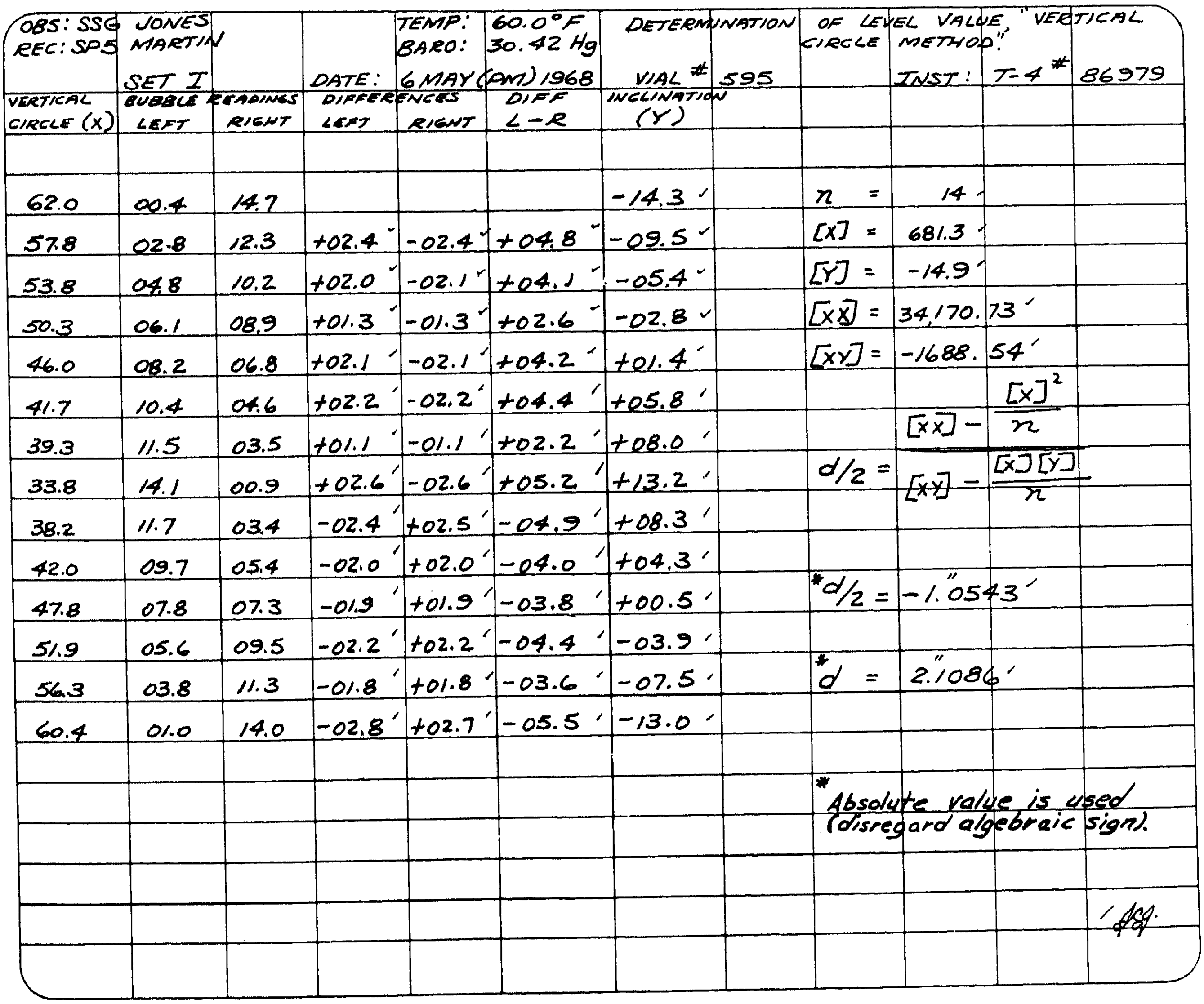
Where:

d = level value in seconds of arc per division of the vial and the *absolute values* are used (the sign of d/2 is disregarded after the formula is computed).

n = number of observations

x = vertical circle readings in seconds of arc (column 1)

y = twice the inclination (column 7)



OBS: SSG JONES
REC: SP5 MARTIN
SET I
DATE: 6 MAY (PM) 1968
TEMP: 60.0°F
BARO: 30.42 Hg
DETERMINATION OF LEVEL VALUE, "VERTICAL CIRCLE METHOD."
VIAL # 595
INST: T-4 # 86979

VERTICAL CIRCLE (X)	BUBBLE READINGS LEFT	BUBBLE READINGS RIGHT	DIFFERENCES LEFT	DIFFERENCES RIGHT	DIFF L−R	INCLINATION (Y)
62.0	00.4	14.7				−14.3
57.8	02.8	12.3	+02.4	−02.4	+04.8	−09.5
53.8	04.8	10.2	+02.0	−02.1	+04.1	−05.4
50.3	06.1	08.9	+01.3	−01.3	+02.6	−02.8
46.0	08.2	06.8	+02.1	−02.1	+04.2	+01.4
41.7	10.4	04.6	+02.2	−02.2	+04.4	+05.8
39.3	11.5	03.5	+01.1	−01.1	+02.2	+08.0
33.8	14.1	00.9	+02.6	−02.6	+05.2	+13.2
38.2	11.7	03.4	−02.4	+02.5	−04.9	+08.3
42.0	09.7	05.4	−02.0	+02.0	−04.0	+04.3
47.8	07.8	07.3	−01.9	+01.9	−03.8	+00.5
51.9	05.6	09.5	−02.2	+02.2	−04.4	−03.9
56.3	03.8	11.3	−01.8	+01.8	−03.6	−07.5
60.4	01.0	14.0	−02.8	+02.7	−05.5	−13.0

n = 14

$[X]$ = 681.3

$[Y]$ = −14.9

$[XX]$ = 34,170.73

$[XY]$ = −1688.54

$$d/2 = \frac{[xx] - \frac{[x]^2}{n}}{[xy] - \frac{[x][y]}{n}}$$

*$d/2$ = −1.″0543

*d = 2.″1086

*Absolute value is used (disregard algebraic sign).

Figure 3-6. Vertical circle method.

(2) *Field computations.* An expedient method of computing the level value is to determine the value for each movement of the bubble and the corresponding change of the vertical circle reading. The formula is—

$$\frac{d}{2} = \frac{\Delta x}{L - R}$$

Where:

d = level value in seconds of arc per division of the vial

Δx = change of the vertical circle readings in seconds of arc between two successive circle readings

L and R = change between successive left and right end readings of the bubble.

e. Probable Error. The summary and probable error are computed in the same way as those for the Wisconsin method (para. 3–2*e*).

f. Allowable Errors and Rejection Limits. The allowable errors and the rejection limits are the same as those specified for the Wisconsin method (para. 3–2*f*).

3–4. Horrebow-Talcott Level Value Determination

The calibration of the Horrebow-Talcott levels is similar to the calibration of the vertical circle level although two observers are needed to make the determination.

a. Procedure.

(1) The length of the bubbles is adjusted to about 20 divisions of the level vial. This is accomplished by tilting the level assembly and allowing liquid to enter or leave the chambers. The telescope is pointed approximately to the zenith and clamped. The vertical axis of the instrument is then carefully leveled.

(2) The level assembly is locked to the horizontal axis of the instrument. The bubbles are then set with the Horrebow level adjusting screw so that they are floating together near one end of the vials and the vertical circle level brought into coincidence. The Horrebow-Talcott levels and the vertical circle level should not be reset during the observations. After allowing the bubbles time to settle (usually about a minute) the ends of both Horrebow-Talcott bubbles are read and recorded together with the left and right ends of the vertical circle bubble. The vertical circle is then brought into final coincidence and the minutes and seconds read. Although only one reading for the seconds of the vertical circle is entered in the record, several coincidences should be made and the mentally computed mean recorded.

(3) The telescope is moved, with the vertical slow motion screw, so that the Horrebow-Talcott bubbles move about two or three divisions. This operation can be facilitated by changing the vertical circle setting by 2 to 3 seconds with the coincidence knob, then bringing the reading back into coincidence with the vertical slow motion screw. After the bubbles have settled all readings are again taken and entered on the record, the Horrebow-Talcott and vertical bubbles, then the vertical circle. This process continues until the bubbles reach the opposite ends of the vials. This comprises one set of observations. The direction of the bubble movement is now reversed and the entire operation repeated until the bubbles have returned to their starting position. This completes one group of observations. Four groups, consisting of two sets each, are required for a complete determination.

b. Notekeeping. The recording is done on DA Form 5–72 as follows (fig. 3–7):

Column 1 and 2. Readings of the left and right ends of the vertical circle level.

Column 3. Vertical circle micrometer reading (x_1).

Column 4 and 5. Reading of the left and right ends of the respective Horrebow-Talcott levels, as the observer faces the level vials. The outside, or lower numbered, vial is read first.

Column 6 and 7. Changes in the readings of the left and right ends of the level vials. If the adjacent value differs by more than 0.2 division, the bubble ends have been incorrectly read.

Column 8. The mean of the successive differences.

Column 9. The mean center of the bubble for each reading y.

Column 10. The corrected vertical circle reading (x). This is determined from $x_1 + d/2(L - R)$, where L and R are the vertical circle level readings and $d/2$ is half the determined level value.

c. Computations. The computations are performed on the recording form. Using the corrected values of the vertical circle readings (x) the following formula is solved for the absolute value of d for both vials:

$$d = \frac{[xx] - \frac{[x]^2}{n}}{[xy] - \frac{[x]\,[y]}{n}}$$

d. Summary of Results and Probable Error. The

OBS: SSG JONES ASS'T OBS: SP5 BLACK
REC: SP5 MARTIN
TEMP: 60.5°F
BAROM: 30.41 Hg
GROUP 3 - A DATE: 6 MAY (PM) 1968
DETM OF HORREBOW-TALCOTT LEVEL VALUES
VERTICAL VIAL VALUE ($d/2$) = 1.″0858 ✓
VIAL # 18 (LOW) VIAL # 41 (HIGH)
INST: T4 #86979

VERTICAL BUBBLE LEFT	VERTICAL BUBBLE RIGHT	MICRO. (X_1)	BUBBLE READINGS LEFT	BUBBLE READINGS RIGHT	DIFFERENCES LEFT	DIFFERENCES RIGHT	MEAN	BUBBLE CENTERS (Y)	CORRECTED MICRO. (X)	REMARKS	
7.2	7.9	59.2	83.2	46.1				64.65 ✓	58.4 ✓		
			183.2	145.1				164.15 ✓			
7.6	7.5	55.8	79.9	42.8	3.3 ✓	3.3 ✓	3.30 ✓	61.35 ✓	55.9 ✓	$d = \frac{[XX] - \frac{[X]^2}{n}}{[XY] - \frac{[X][Y]}{n}}$	
			179.6	141.6	3.6 ✓	3.5 ✓	3.55 ✓	160.60 ✓			
7.6	7.5	52.4	77.3	40.2	2.6 ✓	2.6 ✓	2.60 ✓	58.75 ✓	52.5 ✓	n =	11 ✓
			177.1	139.1	2.5 ✓	2.5 ✓	2.50 ✓	158.10 ✓		[X] =	475.00 ✓
7.9	7.1	49.4	74.0	37.0	3.3 ✓	3.2 ✓	3.25 ✓	55.50 ✓	50.3 ✓	[XX] =	21635.88 ✓
			174.0	136.1	3.1 ✓	3.0 ✓	3.05 ✓	155.05 ✓		18 { [Y] =	536.20 ✓
7.9	7.1	45.8	70.2	33.2	3.8 ✓	3.8 ✓	3.80 ✓	51.70 ✓	46.7 ✓	[XY] =	24286.61 ✓
			170.4	132.6	3.6 ✓	3.5 ✓	3.55 ✓	151.50 ✓		41 { [Y] =	1626.70 ✓
7.9	7.1	42.6	67.1	30.0	3.1 ✓	3.2 ✓	3.15 ✓	48.55 ✓	43.5 ✓	[XY] =	71438.41 ✓
			167.1	129.4	3.3 ✓	3.2 ✓	3.25 ✓	148.25 ✓			18 (LOW) ✓
8.0	7.1	39.5	64.6	27.4	2.5 ✓	2.6 ✓	2.55 ✓	46.00 ✓	40.5 ✓	d =	0.″9929 ✓
			164.5	126.6	2.6 ✓	2.8 ✓	2.70 ✓	145.55 ✓			
7.9	7.1	36.0	61.0	24.0	3.6 ✓	3.4 ✓	3.50 ✓	42.50 ✓	36.9 ✓		41 (HIGH) ✓
			160.9	123.1	3.6 ✓	3.5 ✓	3.55 ✓	142.00 ✓		d =	0.″9414 ✓
7.9	7.3	32.6	57.5	20.6	3.5 ✓	3.4 ✓	3.45 ✓	39.05 ✓	33.3 ✓		
			157.3	119.6	3.6 ✓	3.5 ✓	3.55 ✓	138.45 ✓		CORRECTED MICRO. (X)	
7.9	7.2	29.4	54.1	17.2	3.4 ✓	3.4 ✓	3.40 ✓	35.65 ✓	30.2 ✓	$= (L-R)\frac{d}{2} + (X_1)$	
			153.2	115.4	4.1 ✓	4.2 ✓	4.15 ✓	134.30 ✓			
7.6	7.6	26.8	51.0	14.0	3.1 ✓	3.2 ✓	3.15 ✓	32.50 ✓	26.8 ✓		✓
			147.6	109.9	5.6 ✓	5.5 ✓	5.55 ✓	128.75 ✓			

Figure 3-7. Horrebow-Talcott level calibration (notekeeping).

summary is accomplished on the recording form DA Form 5-72 (fig. 3-8).

e. Probable Errors. Probable errors are computed in the same way as those for the Wisconsin method (para. 3-2*e*).

f. Allowable Errors and Rejection Limits. The allowable errors and rejection limits are the same as those specified for the Wisconson method (para. 3-2*f*).

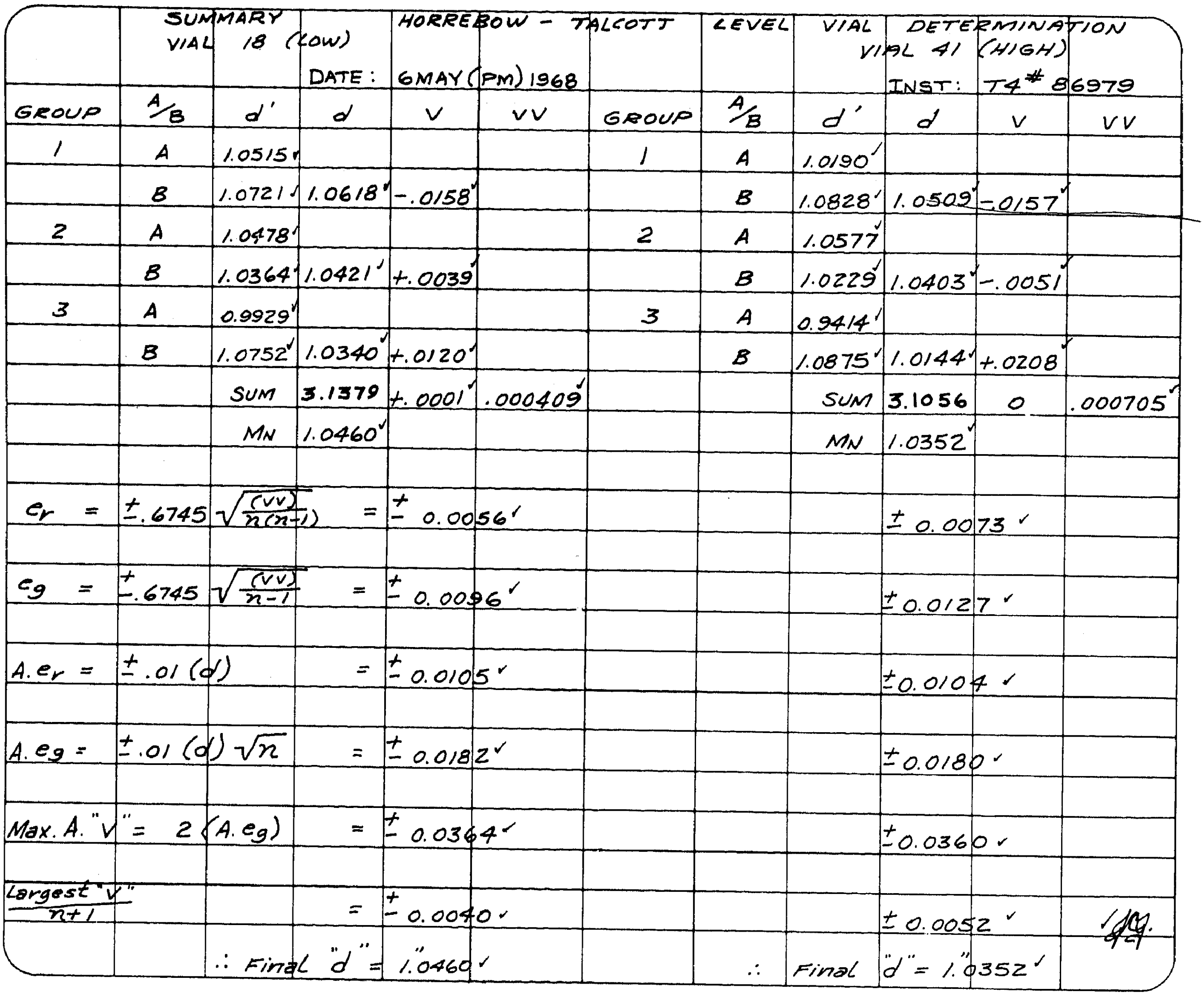
3-5. Calibration With a Level Trier

a. Theory. Determination of the level sensitivity is based on the fact that if one end of the level vial is raised or lowered by a known amount (expressed in seconds of arc) and this amount is divided by the bubble movement (expressed in divisions of the vial) the resulting figure is the sensitivity of the vial in seconds of arc per division. A level trier may be used to make this determination (see para. 3-1*a* for qualification). The level trier (fig. 3-9) is basically a very simple apparatus, consisting fundamentally of a beam pivoted on one end and driven vertically by a micrometer screw at the other. All are mounted on a very stable base and are usually protected by a glass case. The screw moves the beam a known number of seconds of arc (measured at the pivot) per revolution or fraction thereof.

b. Procedure.

(1) The level vial should be securely fastened to the level trier without applying any strain on the vial. The length of the bubble should be made about one-half the length of the vial.

(2) It is imperative that the vial be at room temperature. The vial should remain in the testing room at least 12 hours at a uniform tempera-



	SUMMARY VIAL	18 (LOW)		HORREBOW -	TALCOTT	LEVEL	VIAL	DETERMINATION	VIAL 41 (HIGH)		
			DATE:	6 MAY (PM) 1968				INST:	T4 # 86979		
GROUP	A/B	d′	d	V	VV	GROUP	A/B	d′	d	V	VV
1	A	1.0515				1	A	1.0190			
	B	1.0721	1.0618	-.0158			B	1.0828	1.0509	-.0157	
2	A	1.0478				2	A	1.0577			
	B	1.0364	1.0421	+.0039			B	1.0229	1.0403	-.0051	
3	A	0.9929				3	A	0.9414			
	B	1.0752	1.0340	+.0120			B	1.0875	1.0144	+.0208	
		SUM	3.1379	+.0001	.000409			SUM	3.1056	0	.000705
		MN	1.0460					MN	1.0352		
e_r =	$\pm .6745 \sqrt{\frac{(vv)}{n(n-1)}}$		=	$\pm$ 0.0056					$\pm$ 0.0073		
e_g =	$\pm .6745 \sqrt{\frac{(vv)}{n-1}}$		=	$\pm$ 0.0096					$\pm$ 0.0127		
A. e_r =	$\pm .01 (d)$		=	$\pm$ 0.0105					$\pm$ 0.0104		
A. e_g =	$\pm .01 (d) \sqrt{n}$		=	$\pm$ 0.0182					$\pm$ 0.0180		
Max. A. "V" =	2 (A. e_g)		=	$\pm$ 0.0364					$\pm$ 0.0360		
$\frac{\text{Largest "V"}}{n+1}$			=	$\pm$ 0.0040					$\pm$ 0.0052		
		∴ Final "d" =	1.0460				∴	Final	"d" = 1.0352		

Figure 3-8. Horrebow-Talcott level calibration (summary).

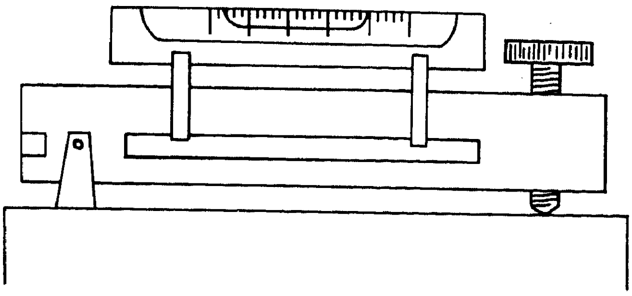


Figure 3-9. Level trier.

ture before testing. A unit of movement for the screw should be chosen that will cause a movement of more than one and less than three graduations of the doubble.

(3) The beam is lowered until the bubble is at one end of the vial. The beam is then moved, by means of the screw, a successive number of whole seconds, the bubble being read and recorded to 0.1 of a division each time, until the bubble is at the opposite end of the vial. This completes one set. The motion is then reversed and the bubble is brought successively back to the other end. The vial is then reversed on the trier and the process is repeated. Sufficient time must be allowed between successive movements to allow the bubble to come to rest.

c. Notekeeping. The test is recorded on DA Form 5-72 as follows (fig. 3-10):

Column 1. Reading of the micrometer screw in graduations.
Column 2. Reading of the micrometer screw in seconds.
Column 3 and 4. Reading of the left and right ends of bubble.
Column 5. Mean center of the bubble.

Column 6. Displacement of the bubble.

d. Computation. Determination of the level sensitivity is made on the recording form DA Form 5-72 (fig. 3-10).

(1) A least squares determination of the level value from each set is computed and the arithmetic mean of the sets is the mean level value, d, in seconds of arc per division:

$$d = \frac{[xx] - \frac{[x]^2}{n}}{[xy] - \frac{[x]\,[y]}{n}}$$

Where:

x = reading of the micrometer on the level trier (seconds of arc)

y = mean reading of the ends of the bubble

n = the number of settings

(2) When the readings of the micrometer increase uniformly by a constant value, D, the numerator of the above equation is then independent of x and always equals—

$$\frac{n\,(n^2 - 1)}{12}\,D^2$$

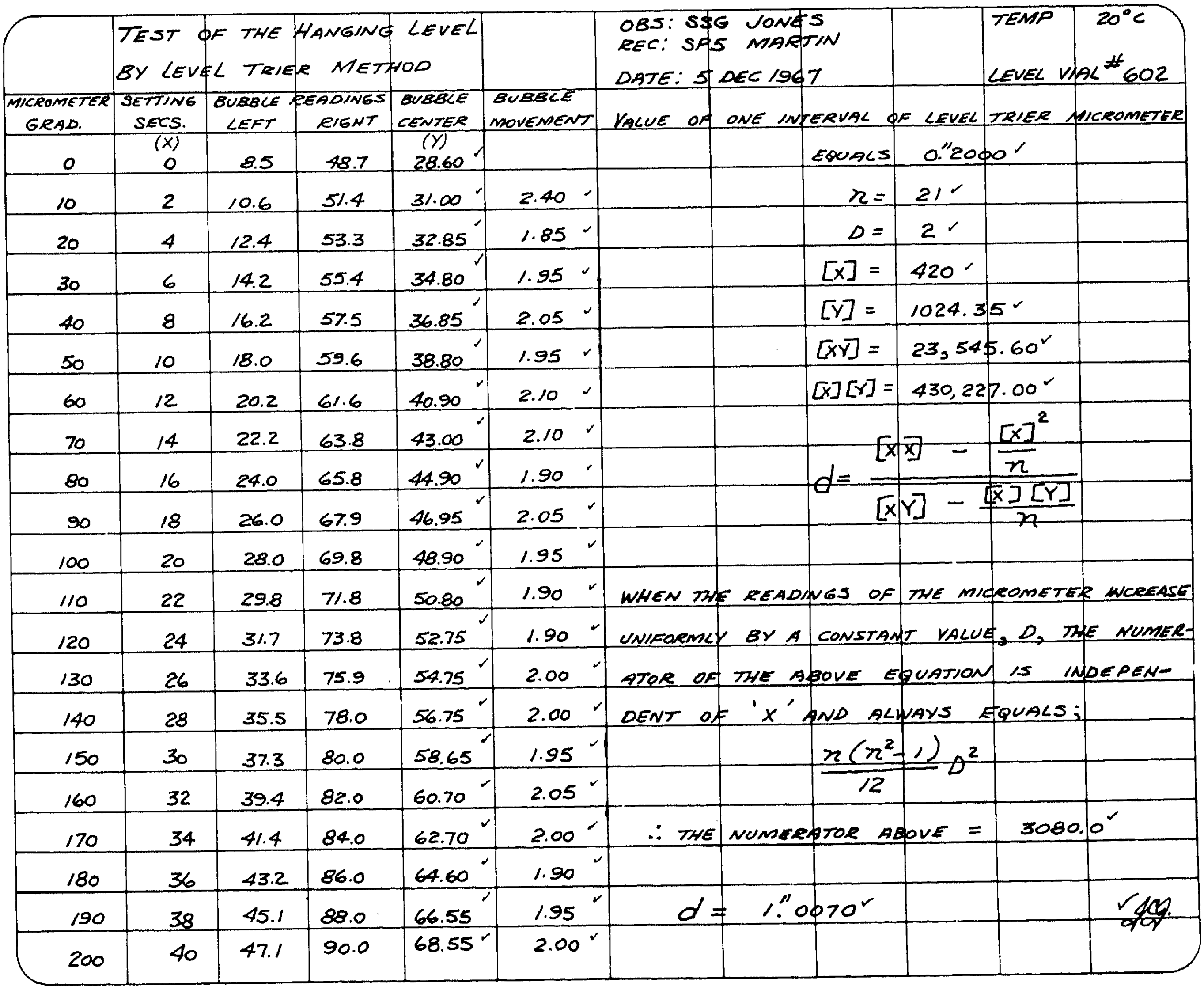
e. Summary of Results and Probable Error. The results are summarized on the recording form DA Form 5-72. The probable error of the mean of the sets is determined from—

$$e_r = \pm\, 0.6745 \sqrt{\frac{[vv]}{n(n-1)}}$$

Where:

v = residual

n = number of sets



TEST OF THE HANGING LEVEL BY LEVEL TRIER METHOD

OBS: SSG JONES
REC: SP5 MARTIN
DATE: 5 DEC 1967

TEMP 20°C
LEVEL VIAL # 602

MICROMETER GRAD.	SETTING SECS. (X)	BUBBLE READINGS LEFT	BUBBLE READINGS RIGHT	BUBBLE CENTER (Y)	BUBBLE MOVEMENT
0	0	8.5	48.7	28.60 ✓	
10	2	10.6	51.4	31.00 ✓	2.40 ✓
20	4	12.4	53.3	32.85 ✓	1.85 ✓
30	6	14.2	55.4	34.80 ✓	1.95 ✓
40	8	16.2	57.5	36.85 ✓	2.05 ✓
50	10	18.0	59.6	38.80 ✓	1.95 ✓
60	12	20.2	61.6	40.90 ✓	2.10 ✓
70	14	22.2	63.8	43.00 ✓	2.10 ✓
80	16	24.0	65.8	44.90 ✓	1.90 ✓
90	18	26.0	67.9	46.95 ✓	2.05 ✓
100	20	28.0	69.8	48.90 ✓	1.95 ✓
110	22	29.8	71.8	50.80 ✓	1.90 ✓
120	24	31.7	73.8	52.75 ✓	1.90 ✓
130	26	33.6	75.9	54.75 ✓	2.00 ✓
140	28	35.5	78.0	56.75 ✓	2.00 ✓
150	30	37.3	80.0	58.65 ✓	1.95 ✓
160	32	39.4	82.0	60.70 ✓	2.05 ✓
170	34	41.4	84.0	62.70 ✓	2.00 ✓
180	36	43.2	86.0	64.60 ✓	1.90 ✓
190	38	45.1	88.0	66.55 ✓	1.95 ✓
200	40	47.1	90.0	68.55 ✓	2.00 ✓

VALUE OF ONE INTERVAL OF LEVEL TRIER MICROMETER EQUALS 0.″2000 ✓

n = 21 ✓

D = 2 ✓

$[X]$ = 420 ✓

$[Y]$ = 1024.35 ✓

$[XY]$ = 23,545.60 ✓

$[X][Y]$ = 430,227.00 ✓

$$d = \frac{[XX] - \frac{[X]^2}{n}}{[XY] - \frac{[X]\,[Y]}{n}}$$

WHEN THE READINGS OF THE MICROMETER INCREASE UNIFORMLY BY A CONSTANT VALUE, D, THE NUMERATOR OF THE ABOVE EQUATION IS INDEPENDENT OF 'X' AND ALWAYS EQUALS;

$$\frac{n\,(n^2 - 1)}{12}\,D^2$$

∴ THE NUMERATOR ABOVE = 3080.0 ✓

d = 1.″0070 ✓

✓ MG.

Figure 3-10. Test of levels using level trier method.

f. Allowable Error and Rejection Limits.

(1) The allowable error, e_r, of the mean should not exceed 0.01 per 1″ of the level determination value.

(2) The bubble movement column of each set should be inspected. Although there are no specific criteria, the bubble movement should not vary by more than ± 0.2 division between consecutive readings. If one section of the vial shows a large change in bubble movement in each set, a "bad spot" is indicated. Although this does not necessarily reject the vial or the determination, the field party must take precautions to avoid bubble reading on this portion of the vial.

Section II. EYEPIECE MICROMETER CONSTANTS

3-6. General

As with level vials, the micrometer constants change, and must frequently be calibrated to determine their values. The determination of the instrument constants should be made at every first-order station, unless several stations are to be observed on a continuing basis in the same locality. Under these conditions, they should be made at every third to fifth station.

3-7. Equatorial Value of the Micrometer

The approximate equatorial value for one turn of the micrometer of the Wild T-4 is 150″. A more accurate value must be determined before any measurements are made with the micrometer. One method is to track low-declination stars through the entire field of view, timing their transit over the fixed wires of the reticle (these wires are one turn apart).

a. Procedure.

(1) Since all stars are at an infinite distance in comparison to terrestrial measurements, all star observations are made with the eyepiece focused at infinity. An infinity stop has been provided by the placement of a capstan head screw at the eyepiece end of the horizontal axis. This stop limits the distance the eyepiece may be pushed into the barrel. Before determination of equatorial value the infinity stop must be set. An extremely clear night and a star of magnitude 4 to 5 are best. Brighter stars create a halo that may be mistaken for an "out of focus" condition. After the star has been brought into best focus the infinity stop is set and then checked with another star. A change in equatorial value will occur whenever there is a change in focus of the eyepiece; therefore, it is important that the focus remain constant. Extreme changes in temperature will also necessitate a new determination.

(2) After the instrument has been accurately leveled and focused it must be placed in the meridian. See chapter 5, Preparation for Observation. The T-4 micrometer is connected to a chronograph which will record the passage of the contact strips under the contact points of the micrometer. A chronometer is also connected to the chronograph to record the time of the contact of the strips. At least four equatorial stars (that is, stars with declinations as close to zero as possible) are tracked across the field of view. One complete determination consists of tracking each star across the field of view from the 05 wire to the 15 wire resulting in 10 complete turns of the micrometer drum. The instrument is not reversed during this observation. The recorder need only enter the star numbers and the date of the observations on the chonograph record.

b. Computations.

(1) After the observations are completed the record is scaled to determine the times of transit of the star over the fixed wires. The fixed wires are indicated on the record by the "zero" contact strip.

(2) The scaling and computation are done on DA Form 5-72 (fig. 3-11). The scaled times of the "zero" contact strips are entered in the second column of the form. The differences in time between successive breaks are entered in column 3. Values that are obviously in error are rejected and a mean taken of the remaining values. The equatorial value R of the micrometer is then computed from the formula:

$$R = t \cos \delta$$

Where:

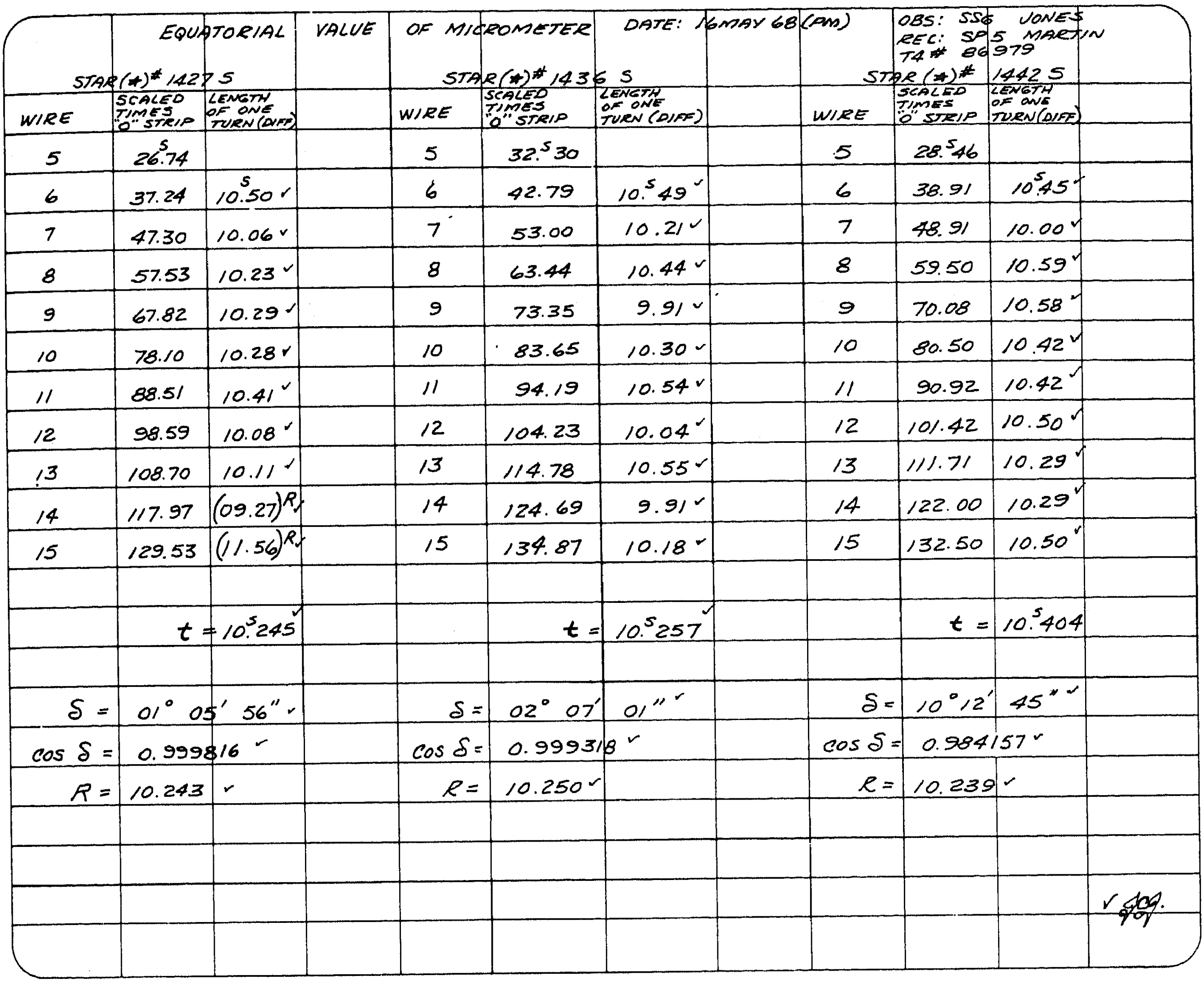
t = difference of sidereal times between "zero" contacts

$\cos \delta$ = cosine of the star's declination. This reduces the value from the diurnal circle of the star's declination to the great circle at the equator.

A mean of four such determinations is usually accurate enough for determining instrument constants. If the values appear erratic, then all of the contact strip breaks should be scaled and a mean of 10 breaks used for each turn of the micrometer.

3-8. Mean Width of Contact Strips

a. As a star is tracked with the movable wire the micrometer contact drum is also turning. As soon as the leading edge of the contact strip makes



EQUATORIAL VALUE OF MICROMETER DATE: 16 MAY 68 (PM)

OBS: SSG JONES
REC: SP5 MARTIN
TA # 86979

STAR (✱)# 1427 S			STAR (✱)# 1436 S			STAR (✱)# 1442 S		
WIRE	SCALED TIMES "O" STRIP	LENGTH OF ONE TURN (DIFF)	WIRE	SCALED TIMES "O" STRIP	LENGTH OF ONE TURN (DIFF)	WIRE	SCALED TIMES "O" STRIP	LENGTH OF ONE TURN (DIFF)
5	$26^{s}.74$		5	$32^{s}.30$		5	$28^{s}.46$	
6	37.24	$10^{s}.50$ ✓	6	42.79	$10^{s}.49$ ✓	6	38.91	$10^{s}.45$ ✓
7	47.30	10.06 ✓	7	53.00	10.21 ✓	7	48.91	10.00 ✓
8	57.53	10.23 ✓	8	63.44	10.44 ✓	8	59.50	10.59 ✓
9	67.82	10.29 ✓	9	73.35	9.91 ✓	9	70.08	10.58 ✓
10	78.10	10.28 ✓	10	83.65	10.30 ✓	10	80.50	10.42 ✓
11	88.51	10.41 ✓	11	94.19	10.54 ✓	11	90.92	10.42 ✓
12	98.59	10.08 ✓	12	104.23	10.04 ✓	12	101.42	10.50 ✓
13	108.70	10.11 ✓	13	114.78	10.55 ✓	13	111.71	10.29 ✓
14	117.97	$(09.27)^{R}$ ✓	14	124.69	9.91 ✓	14	122.00	10.29 ✓
15	129.53	$(11.56)^{R}$ ✓	15	134.87	10.18 ✓	15	132.50	10.50 ✓
	t =	$10^{s}.245$ ✓		t =	$10^{s}.257$ ✓		t =	$10^{s}.404$
δ =	01° 05′ 56″ ✓		δ =	02° 07′ 01″ ✓		δ =	10° 12′ 45″ ✓	
cos δ =	0.999816 ✓		cos δ =	0.999318 ✓		cos δ =	0.984157 ✓	
R =	10.243 ✓		R =	10.250 ✓		R =	10.239 ✓	

Figure 3-11. Equatorial value of micrometer.

contact with the platinum point, an electronic circuit is completed causing a mark of the event to be recorded on the chronograph. After the star is tracked part way into the field of view the telescope is reversed and the star is tracked out of the field of view with the contact drum turning in the opposite direction. This causes the other edge of the strip to make the first contact with the point. It is apparent that the breaks are recorded too soon by one-half the width of the contact strips. During longitude observations the star is tracked into the field of view a distance corresponding to about two and a half turns of the micrometer, causing all of the strips to make contact with the platinum point. Since all of the strips are used and all are approximately the same width, a mean of all the strips (except the two identification strips) must be determined.

b. One method of determining width of strips is to connect an ohm meter in series with the micrometer terminals. As the micrometer drum is turned, bringing the leading edge of the contact strip into contact with the platinum point, the circuit is closed and will be so indicated on the meter. As soon as the ohm meter indicates a reading, the turning is stopped immediately and the micrometer scale is read and the value is recorded. Turning of the drum is continued slowly in the same direction until the circuit is broken. The micrometer scale is again read and recorded. This process is continued until readings have been taken on both edges of all contact strips. This constitutes one set of observations. Twenty sets are required for a determination of mean width of strips; ten sets observed with the drum motion in one direction and 10 sets in the opposite direction.

c. DA Form 5-72 is used for recording the determination of mean width of contact strips (fig. 3-12). Each set requires the use of four columns.

Column 1. Number of contact strip.
Column 2. Reading of the micrometer scale as the strip comes into contact (ON).
Column 3. Reading of the micrometer scale as contact is broken (OFF).
Column 4. Width of strip. Larger value minus the smaller corresponding value. A mean width is taken for each set. A mean of 20 sets is the mean width of contact strips expressed in divisions of the micrometer scale.

3-9. Lost Motion

a. Theory.

(1) Any part moved by a screw against the pressure of a spring tends to have a certain amount of lost motion (backlash). This is true of the movable wire in the eyepiece micrometer. When the screw is turned so that the wire moves upward, the coil springs in the micrometer box are compressed. Conversely when the motion of the screw is reversed the springs are partially released.

(2) To show the effect of lost motion assume that a star moves from left to right and that the times are recorded with the star at wire positions 1, 2, 3, and 4, consecutively (fig. 3-13). The instrument is then reversed and the times are again recorded when the star is in the corresponding wire positions 4′, 3′, 2′, and 1′. However, due to lost motion the micrometer begins to move before the wire, indicating that the star is in positions 4″, 3″, 2″, and 1″, respectively. It is evident that the

OBS: SSG REC: SP-5	JONES MARTIN		TEMP:	62°F		DETERMINATION STRIPS	OF MEAN WIDTH (STATIC METHOD)	OF CONTACT			
SET 1 THRU 4			DATE: 9	MAY 68					INST. #	T-4 86979	
STRIP NO.	(−) ON	(+) OFF	WIDTH		STRIP NO.	(−) ON	(+) OFF	WIDTH	REMARKS		
0	99.7	00.4	0.7 ✓		0	99.7	00.2	0.5 ✓			
1	09.7	10.5	0.8 ✓		1	09.7	10.4	0.7 ✓			
2	19.7	20.4	0.7 ✓		2	19.7	20.3	0.6 ✓			
3	29.6	30.3	0.7 ✓		3	29.6	30.3	0.7 ✓			
4	39.6	40.3	0.7 ✓		4	39.6	40.4	0.8 ✓			
5	49.7	50.3	0.6 ✓		5	49.6	50.4	0.8 ✓			
6	59.7	60.2	0.5 ✓		6	59.6	60.3	0.7 ✓			
7	69.7	70.2	0.5 ✓		7	69.7	70.3	0.6 ✓			
8	79.6	80.3	0.7 ✓		8	79.7	80.2	0.5 ✓			
9	89.7	90.2	0.5 ✓		9	89.7	90.3	0.6 ✓			
		MEAN	0.640 ✓				MEAN	0.650 ✓			
0	99.7	00.3	0.6 ✓		0	99.7	00.4	0.7 ✓			
1	09.7	10.4	0.7 ✓		1	09.7	10.4	0.7 ✓			
2	19.7	20.4	0.7 ✓		2	19.7	20.4	0.7 ✓			
3	29.7	30.3	0.6 ✓		3	29.6	30.3	0.7 ✓			
4	39.6	40.3	0.7 ✓		4	39.6	40.4	0.8 ✓			
5	49.7	50.3	0.6 ✓		5	49.6	50.3	0.7 ✓			
6	59.6	60.2	0.6 ✓		6	59.6	60.3	0.7 ✓			
7	69.6	70.3	0.7 ✓		7	69.7	70.3	0.6 ✓			
8	79.7	80.3	0.6 ✓		8	79.7	80.3	0.6 ✓			✓
9	89.7	90.3	0.6 ✓		9	89.7	90.4	0.7 ✓			
		MEAN	0.640 ✓				MEAN	0.690 ✓			

Figure 3-12. Determination of mean width of contact strips.

times after reversal would all be recorded early by the amounts $(4'' - 4')$, $(3'' - 3')$, etc., and that the correction would be one-half the time interval represented by the mean of these amounts. For stars observed beginning with the instrument in the reversed position the first half of the positions are observed early and the same correction must be applied.

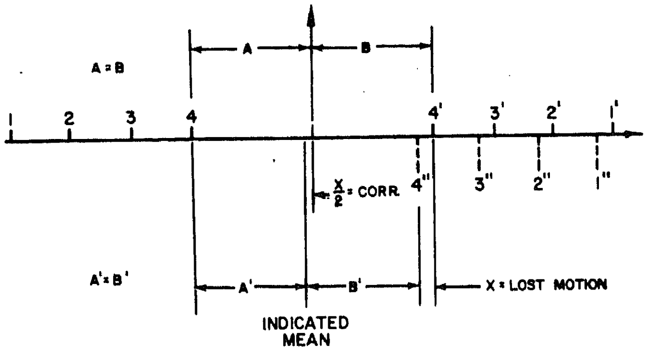


Figure 3–13. Lost motion.

b. Kinds of Lost Motion. There are two kinds of lost motion, dynamic and static. Although desirable, dynamic lost motion (lost motion of the wire in motion) is not usually determined, because the necessary equipment is elaborate and not generally available. Static lost motion, however, can be approximated by the following procedures.

c.Procedure for Determining Static Lost Motion.

(1) Lost motion is determined in three positions of the telescope, at zenith distances of 30°, 0°, and 330°, as positioned by the zenith distance setting circle. The observing is performed upon the stationary wires and requires very careful bisection and close concentration on the part of the observer. The eyepiece must be so illuminated and focused that the wires appear as sharp black lines on a clear background.

(2) With the telescope set, begin by placing the movable wire between the "05" and the "06" wires. Turn the handwheels so as to increase the micrometer readings until the movable wire bisects the "06" wire. Record the micrometer reading as an *increase* value for the "06" wire for that telescope setting.

(3) Continue in the increasing manner until the movable wire is in coincidence with the "07" wire. Record the reading as an *increase* reading for the "07" wire.

(4) One determination consists of recording the coincidences of the movable wire on the 6, 7, 8, 9, 10, 11, 12, 13, and 14 wires. With the telescope in one zenith position, coincidences are made in the increasing ("up") direction at each of the wires and then coincidences are made in the decreasing ("down") direction at each of the wires. This completes one set or a total of 18 readings. This procedure is repeated five times for a total of 90 readings in *each* of the three telescope positions. A mean of all observations is the approximate static lost motion (m).

(5) If it is felt that a bisection or coincidence was poorly made the observer should back off about ½ turn of the micrometer and reobserve. Always insure that the micrometer readings are increasing when making increasing readings or decreasing when making decreasing readings. A partial determination of the lost motion in one telescope position is shown in figure 3–14.

d. Recording. DA Form 5–72 is used for recording the determination of lost motion (fig. 3–14).

Column 1.	The wire being read.
Column 2.	The micrometer reading when the the wire was moved into coincidence with increasing scale readings.
Column 3.	The micrometer reading when the the wire was moved into coincidence with decreasing scale readings.
Column 4.	Difference, or lost motion (column 2 minus column 3).

3–10. Determination of Micrometer Constant

a. Lost Motion Correction. The formula for the correction to be applied to the observed transit time of the star for lost motion is—

$$\text{Corr} = \frac{1}{2} \cdot \frac{R}{100}\,(m)\,(\sec\delta)$$

Where:

R = equatorial value of micrometer in sidereal seconds of time

m = lost motion

δ = declination of the star

b. Width of Strip Correction. The formula for the correction to be applied to the observed transit time of the star for mean width of contact strips is —

$$\text{Corr} = \frac{1}{2} \cdot \frac{R}{100}\,(s)\,(\sec\delta)$$

Where:

R = equatorial value of the micrometer in sidereal seconds of time

s = mean width of contact strips

δ = declination of the star

c. Micrometer Constant (l). Since the corrections for lost motion and width of contact strips each involve

$$\frac{1}{2} \cdot \frac{R}{100} \text{ and } \sec \delta,$$

they are combined into one correction. The formula for l is—

$$l = \frac{R}{200}\ (m + s)\ (\sec \delta)$$

sec δ is the only variable in the formula, and

$$\frac{1}{2} \cdot \frac{R}{100}\ (m + s)$$

is the micrometer constant for all stars.

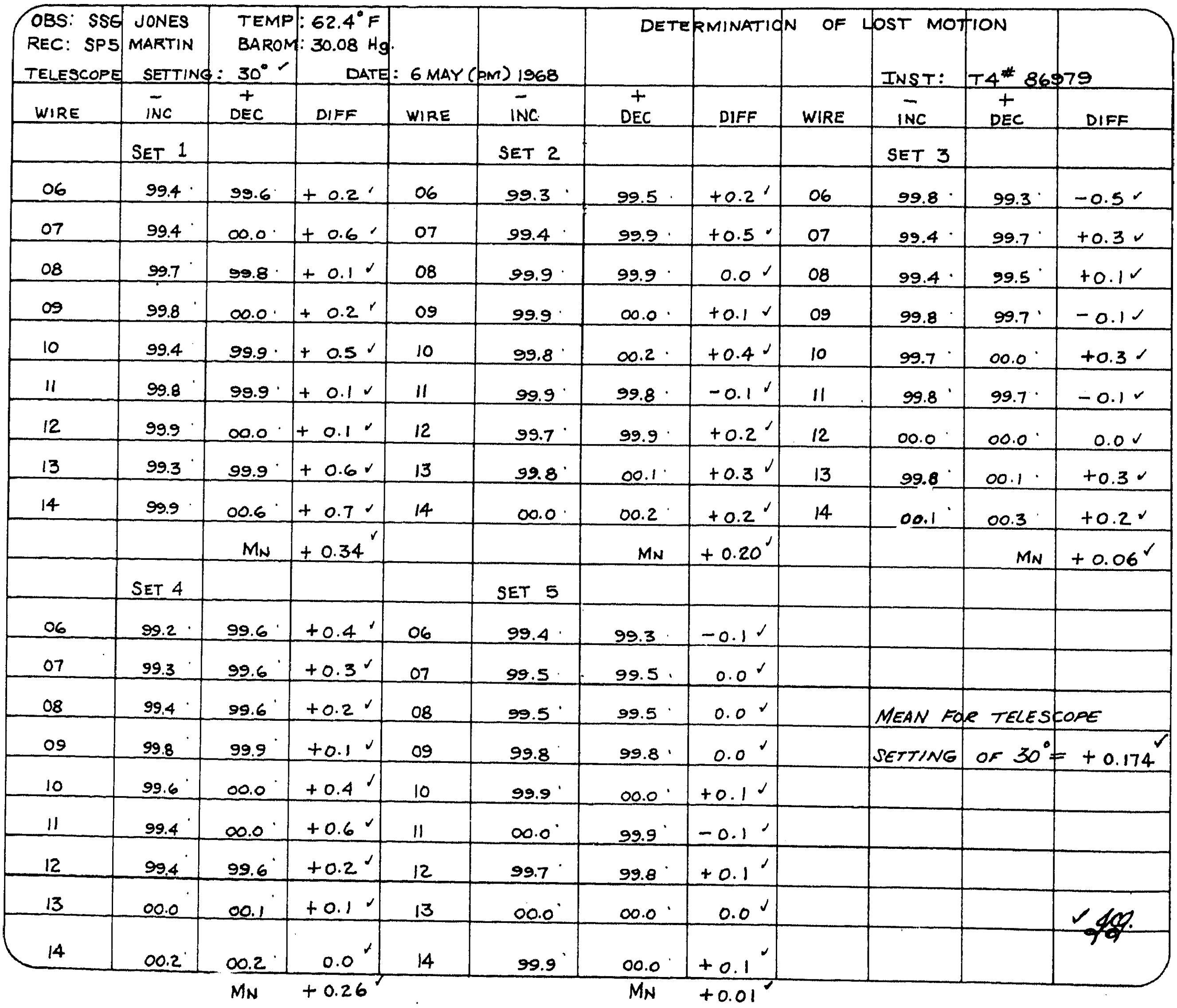
3-11. Alternate Method of Determining Width of Strips by Scaling

A method of determining the effective width of contact strips by scaling longitude star records is generally accepted. This method can be used to verify or be used in lieu of field determinations. Since the procedures are the same as for the determination of the equatorial value, both determinations may be solved at one time.

a. The chronograph record of several low-declination stars (minimum of four) is selected from the longitude observations. The record is selected for quality of the markings and the uniformity of contact breaks. Two to three revolutions of the contact drum are selected from the in-track, and both edges of the break are scaled to the one-hundredth of a second and their values recorded. The corresponding turns on the out-track are treated in a like manner.

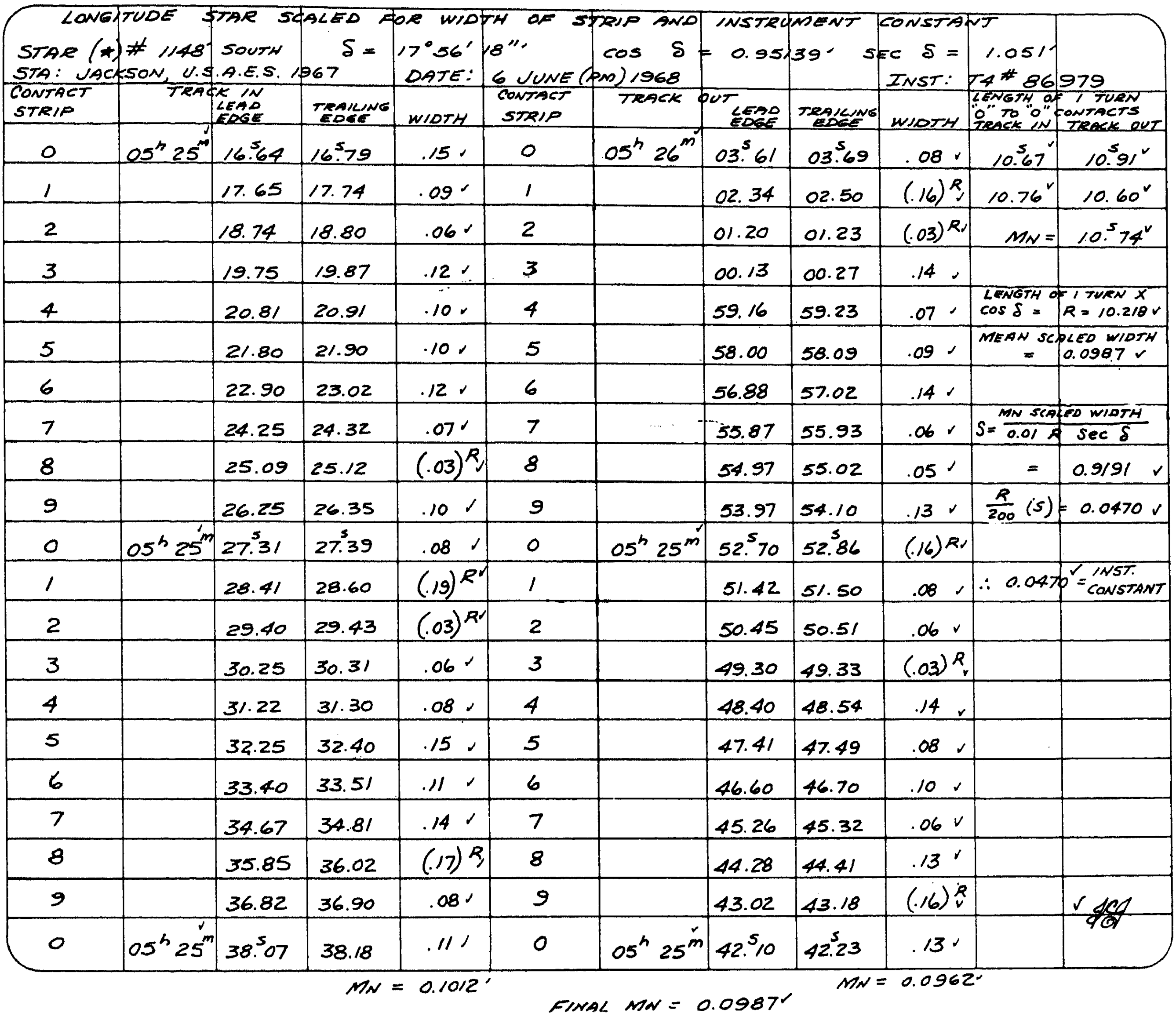
b. The recording is done on DA Form 5-72 as follows (fig. 3-15):

Column 1 and 6. Strip designator.
Column 2, 3, and 4. Chronometer time of the make and the break for that contact on the track-in.



OBS: SSG REC: SP5	JONES MARTIN	TEMP BAROM	: 62.4° F : 30.08 Hg.			DETERMINATION OF LOST MOTION					
TELESCOPE SETTING: 30° ✓				DATE: 6 MAY (PM) 1968					INST:	T4# 86979	
WIRE	− INC	+ DEC	DIFF	WIRE	− INC	+ DEC	DIFF	WIRE	− INC	+ DEC	DIFF
	SET 1				SET 2				SET 3		
06	99.4	99.6	+ 0.2 ✓	06	99.3	99.5	+0.2 ✓	06	99.8	99.3	−0.5 ✓
07	99.4	00.0	+ 0.6 ✓	07	99.4	99.9	+0.5 ✓	07	99.4	99.7	+0.3 ✓
08	99.7	99.8	+ 0.1 ✓	08	99.9	99.9	0.0 ✓	08	99.4	99.5	+0.1 ✓
09	99.8	00.0	+ 0.2 ✓	09	99.9	00.0	+0.1 ✓	09	99.8	99.7	−0.1 ✓
10	99.4	99.9	+ 0.5 ✓	10	99.8	00.2	+0.4 ✓	10	99.7	00.0	+0.3 ✓
11	99.8	99.9	+ 0.1 ✓	11	99.9	99.8	−0.1 ✓	11	99.8	99.7	−0.1 ✓
12	99.9	00.0	+ 0.1 ✓	12	99.7	99.9	+0.2 ✓	12	00.0	00.0	0.0 ✓
13	99.3	99.9	+ 0.6 ✓	13	99.8	00.1	+0.3 ✓	13	99.8	00.1	+0.3 ✓
14	99.9	00.6	+ 0.7 ✓	14	00.0	00.2	+0.2 ✓	14	00.1	00.3	+0.2 ✓
		MN	+ 0.34 ✓			MN	+ 0.20 ✓			MN	+ 0.06 ✓
	SET 4				SET 5						
06	99.2	99.6	+0.4 ✓	06	99.4	99.3	−0.1 ✓				
07	99.3	99.6	+0.3 ✓	07	99.5	99.5	0.0 ✓				
08	99.4	99.6	+0.2 ✓	08	99.5	99.5	0.0 ✓		MEAN FOR TELESCOPE		
09	99.8	99.9	+0.1 ✓	09	99.8	99.8	0.0 ✓		SETTING	OF 30° =	+ 0.174 ✓
10	99.6	00.0	+ 0.4 ✓	10	99.9	00.0	+0.1 ✓				
11	99.4	00.0	+0.6 ✓	11	00.0	99.9	−0.1 ✓				
12	99.4	99.6	+0.2 ✓	12	99.7	99.8	+0.1 ✓				
13	00.0	00.1	+0.1 ✓	13	00.0	00.0	0.0 ✓				✓
14	00.2	00.2	0.0 ✓	14	99.9	00.0	+0.1 ✓				
		MN	+ 0.26 ✓			MN	+0.01 ✓				

Figure 3-14. Recording lost motion.



LONGITUDE STAR SCALED FOR WIDTH OF STRIP AND INSTRUMENT CONSTANT											
STAR (★) # 1148	SOUTH	$\delta =$	17° 56′ 18″ ✓		COS δ = 0.95139 ✓			SEC δ =	1.051 ✓		
STA: JACKSON, U.S.A.E.S. 1967			DATE:	6 JUNE (PM) 1968				INST:	T4 # 86979		
CONTACT STRIP	TRACK IN	LEAD EDGE	TRAILING EDGE	WIDTH	CONTACT STRIP	TRACK OUT	LEAD EDGE	TRAILING EDGE	WIDTH	LENGTH OF 1 TURN "0" TO "0" CONTACTS TRACK IN	TRACK OUT
0	$05^h 25^m$ ✓	$16^s.64$	$16^s.79$	.15 ✓	0	$05^h 26^m$ ✓	$03^s.61$	$03^s.69$	.08 ✓	$10^s.67$ ✓	$10^s.91$ ✓
1		17.65	17.74	.09 ✓	1		02.34	02.50	$(.16)^R$ ✓	10.76 ✓	10.60 ✓
2		18.74	18.80	.06 ✓	2		01.20	01.23	$(.03)^R$ ✓	MN =	$10^s.74$ ✓
3		19.75	19.87	.12 ✓	3		00.13	00.27	.14 ✓		
4		20.81	20.91	.10 ✓	4		59.16	59.23	.07 ✓	LENGTH OF 1 TURN X COS δ =	R = 10.218 ✓
5		21.80	21.90	.10 ✓	5		58.00	58.09	.09 ✓	MEAN SCALED WIDTH =	0.0987 ✓
6		22.90	23.02	.12 ✓	6		56.88	57.02	.14 ✓		
7		24.25	24.32	.07 ✓	7		55.87	55.93	.06 ✓	$S=\frac{\text{MN SCALED WIDTH}}{0.01\ R\ \sec\delta}$	
8		25.09	25.12	$(.03)^R$ ✓	8		54.97	55.02	.05 ✓	=	0.9191 ✓
9		26.25	26.35	.10 ✓	9		53.97	54.10	.13 ✓	$\frac{R}{200}(S)$	= 0.0470 ✓
0	$05^h 25^m$ ✓	$27^s.31$	$27^s.39$	.08 ✓	0	$05^h 25^m$ ✓	$52^s.70$	$52^s.86$	$(.16)^R$ ✓		
1		28.41	28.60	$(.19)^R$ ✓	1		51.42	51.50	.08 ✓	∴ 0.0470 ✓	= INST. CONSTANT
2		29.40	29.43	$(.03)^R$ ✓	2		50.45	50.51	.06 ✓		
3		30.25	30.31	.06 ✓	3		49.30	49.33	$(.03)^R$ ✓		
4		31.22	31.30	.08 ✓	4		48.40	48.54	.14 ✓		
5		32.25	32.40	.15 ✓	5		47.41	47.49	.08 ✓		
6		33.40	33.51	.11 ✓	6		46.60	46.70	.10 ✓		
7		34.67	34.81	.14 ✓	7		45.26	45.32	.06 ✓		
8		35.85	36.02	$(.17)^R$ ✓	8		44.28	44.41	.13 ✓		
9		36.82	36.90	.08 ✓	9		43.02	43.18	$(.16)^R$ ✓		✓
0	$05^h 25^m$ ✓	$38^s.07$	38.18	.11 ✓	0	$05^h 25^m$ ✓	$42^s.10$	$42^s.23$	.13 ✓		

MN = 0.1012 ✓

MN = 0.0962 ✓

FINAL MN = 0.0987 ✓

Figure 3-15. Micrometer constants from chronograph scaling.

Column 5 and 10. Width of strip for track-in and track-out, i.e., difference in time of columns 3 and 4 and 8 and 9 respectively.

Column 7, 8, and 9. Chronometer time of the make and break for that contact on the track-out.

c. The mean width of strips is computed on the recording form. If the equatorial value of the micrometer is known the width of strips may be computed from the formula:

$$s = \frac{\text{mean scaled width in time}}{0.01\,R \sec\delta}$$

Where:

s = mean effective width of strips in divisions of the micrometer
R = equatorial value of the micrometer
δ = declination of the star

If the equatorial value is not known it can be determined from the scaled values. The length of one turn is first determined by computing the time difference between successive passages of the zero strip and meaning them. This mean value is then multiplied by cos δ to obtain the equatorial value.

d. s may also be computed by the following formula:

$$s = \frac{100 \sum_{o}^{n} s_i}{D_n}$$

Where:

s = mean effective width of strip in divisions of the micrometer
n = total number of strips scaled
s_i = scaled width of strip
D = total distance from first strip scaled to last strip scaled (distance between $sn - s_i$)

e. A variation of this method of determining the effective width of strip can be accomplished using a constant speed motor to drive the micrometer. The method of computing s as described in paragraph *d* above is most applicable when a constant speed motor is utilized.

CHAPTER 4

EQUIPMENT

4–1. General

The equipment presently authorized in DA Supply Catalog SC 6675–93–CL–E34, Surveying Set, Astronomic Position (FSN 6675–641–8897) requires supplementation and modification to permit the necessary observations and computations. A suggested list of needed equipment is given in paragraph 4–11.

4–2. Timing Equipment

a. Throughout the observations there is a requirement for time determination. The requirement for latitude and azimuth can be adequately met with the use of a chronometer and a radio receiver. The observations for longitude are dependent upon very precise time determinations and the equipment is more complex. Essentially the requirement for time determinations can be met with a radio, chronometer, the T–4 eyepiece micrometer, and a recording device. A block diagram of the equipment is shown in figure 4–1.

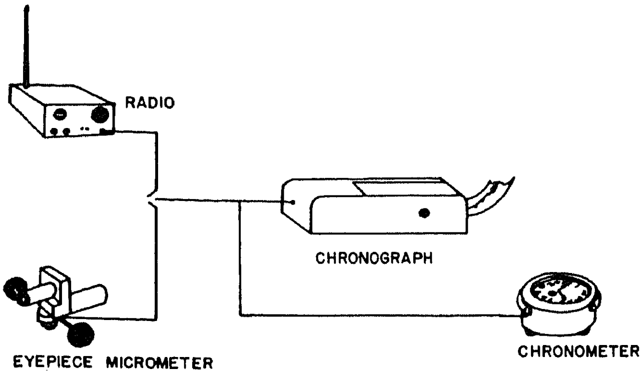


Figure 4–1. Timing equipment block diagram.

b. The actual components and connections of the timing equipment are more complex than this simplified diagram. Modification, purchase of additional components, and fabrication are necessary to produce an operable system from the equipment issued with the survey set. Each component will be considered in detail in the following paragraphs. The required timing equipment ensemble more nearly resembles figure 4–2. Usually the audio filter and amplifier are incorporated in the connection and control box.

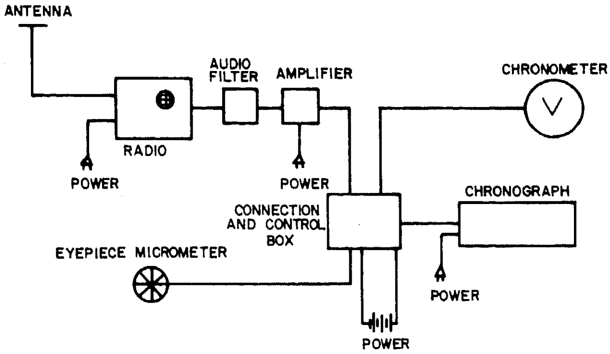


Figure 4–2. Timing equipment components.

4–3. Break Circuit Chronometers

a. Chronometers are usually designated by the type of time they are rated for, solar or sidereal. A sidereal chronometer is recommended, although a mean time (solar) chronometer may be utilized, if necessary. Regardless of the type of time kept by the chronometer it should have a rate that is linear with respect to time.

b. The 2-second break circuit chronometer is the most desirable of the mechanical types, as it records a sufficient density of signals on the chronograph record to enable the time to be accurately scaled. Usually the contacts operate every even second and also on the 59th second for the identification of the minute. The 10-second break circuit chronometer is not recommended because chronograph rate fluctuation between successive 10-second recordings may be large enough to result in erroneous results in the time scaled on the chronograph tape.

c. Chronometers are precision instruments and must be handled accordingly. Sudden jars, swinging, or oscillatory movement should be avoided. Oscillatory motion may cause a chronometer to gain or lose several seconds, and in extreme cases it may actually stop. The iron case serves not only as a protective shell but also as a magnetic shield. A chronometer which has become magnetized invariably develops an erratic rate. The chronometer should be removed from the iron case only when absolutely necessary for setting or immobilizing. It should be kept well away from electrical generators, transformers, and magnetic materials at all times. If it should become magnetized, it must be demagnetized by a professional watchmaker. No adjustment of any kind should ever be attempted in the field.

d. No attempt is made to temperature-control a chronometer in the field. The temperature compensation of chronometers manufactured by leading companies is exceptionally good, but a chronometer must not be expected to maintain a perfectly constant rate through even moderate changes. Chronometers should never be moved in the field from heated quarters to open air positions or vice versa. Even under extreme conditions the chronometer should remain at the actual observing site, being protected from the direct effects of sunlight, rain, or snow by a simple shelter.

e. Ordinarily, chronometers arrive in the field fully wound but with the balance wheel immobilized. The newer chronometers contain an immobilizing mechanism that is operated by a small hexagonal key. To release the balance wheel the key is inserted into the keyway and turned counterclockwise. With older chronometers the balance wheel is immobilized by two cork or plastic wedges placed under the rim of the balance wheel. To remove the wedges and start the movement is a delicate operation and must be performed carefully to avoid damaging the mechanism. The chronometer is first removed from the carrying case, and the glass top unscrewed. It is then turned face down by grasping the dial edge with the fingers of one hand and the bottom of the mechanism case with the other hand. In this inverted position it is easy to lift the case from the chronometer works. It will be convenient to support the mechanism by placing it face downward in the empty case. The wedges under the balance wheel should now be carefully removed, with tweezers. The mechanism is then inverted and returned to the case. Some older chronometers have had a small locking device installed which slips over a weight-adjustment screw on the balance wheel to immobilize the wheel.

f. The hands may be set to any desired hour and minute by inserting the winding key on the pivot shaft carrying the hands and turning them *clockwise.* The minute hand should be synchronized with the second hand. Finally, the glass cover must be screwed in place and the chronometer returned to the carrying case. The instrument is started by holding it in a horizontal position and giving it a sharp turn in either the clockwise or counterclockwise direction. It should not be oscillated from one direction to another. The chronometer should be wound at a regular interval, and this is usually done after completion of a night's observations. The chronometer should always be allowed to run from 4 to 6 hours prior to an observation to stabilize the rate. The chronometer should *never* be moved or jarred during an observation for longitude. Additionally, the chronometer should *never* be wound when it is removed from the brass case. There are two winding shafts visible when the chronometer is out of the case, and winding the wrong one will necessitate return of the chronometer to a watchmaker for repair.

g. If a chronometer is to be moved any distance or shipped, it must be stopped and immobilized. With the newer chronometers these actions are performed with the immobilizing mechanism. To stop and immobilize the older chronometers, remove the mechanism from its case and permit the balance wheel to come lightly into contact with a slip of paper or a camel's-hair brush until the wheel ceases to move. Only light pressure should be used in this operation. Two soft wedges are then gently inserted on opposite sides of the balance wheel rim about where the spokes of the wheel join the rim. They should be put firmly in place but never forced. The immobilized instrument is then returned to its case and fully wound. Excelsior or other dusty materials should never be used for packing. A good grade of paper is satisfactory. If possible, the chronometer should always be hand carried.

4-4. Crystal-controlled Timing Devices

Portable crystal clocks, having frequency oscillators of sufficient accuracy for astronomic work, have been developed and are available for general use. U.S. Army Topographic Command (TOPOCOM) has conducted tests on several of these clocks and has found that interpolated times between radio-chronometer comparisons, separated by as much as 24 hours, are reliable to within ± 0.001 second. Clocks with this accuracy, if adopted into the system, will allow time comparisons to be recorded during ideal radio reception periods, and will partially eliminate the problems presently encountered with the multiple signal receptions during observations.

4-5. Chronographs

In order to transform time signals, star tracking, and chronometer signals into a visible record, a recording chronograph is used. There are several types of chronographs available. The Brush Oscillograph is issued with the set. The drum chronograph is a commercially obtainable item. Information on the manufacturer is available at TOPOCOM. Depending upon project commitments, it may be possible to obtain the loan of a drum chronograph from TOPOCOM. Throughout the text the term chronograph will be used to refer to any type of graphic recording device.

a. Drum Chronograph. The drum chronograph is desirable because of the ease with which star transit scalings can be made, its 10mm/sec chart speed, low paper consumption, and battery operation. Because of its slow speed, and since it is not equipped with an oscillating type of recording pen, the drum chronograph cannot be used to record radio-chronometer comparisons. An oscillograph such as the Brush model 220 must be used since it is possible, in most cases, to identify the radio transmitting station from the record. If a drum chronograph is not available, an oscillograph may be used for recording star transits, but the amount of chart paper used by the oscillograph during a longitude observation is considered to be excessive and the scaling of strip chart records is much more difficult than scaling a drum chronograph record.

b. Oscillograph.

(1) The Brush Model RD 2322–00 oscillograph is issued with the set. Previously the Brush Model BL–222 was issued and may still be encountered. Differences between the two models are in detail only. A variable speed chart takeup is also issued. The chart takeup may be left turned on for short periods of time, while the oscillograph is not running.

(*a*) The oscillograph has three chart speeds, 5 mm/sec, 25 mm/sec, and 125 mm/sec. The speed of 25 mm/sec is used for radio-chronometer comparisons and the 125 mm/sec speed is used for time signal identification. As the star transits must be recorded at a minimum speed of 10 mm/sec, the 5 mm/sec speed is not usable, necessitating the use of 25 mm/sec speed. This results in excessive paper consumption and is also more difficult to scale than a 10 mm/sec speed; therefore, converting the 5 mm/sec speed to a 10 mm/sec speed is recommended.

(*b*) Converting the speeds requires fabrication of replacement gears for the oscillograph. Most well-equipped machine shops can make the modification. The gears which must be replaced and dimensions for the replacement gears are shown in figure 4–3. Gear changes can be made by the manufacturer at a nominal cost.

(2) It is planned that the Brush Mark 220 oscillograph will be introduced into the set in the near future. The Mark 220 has several significant features; among them are the transistorized amplifier circuits included in each recording channel. Use of the amplifier circuits in the oscillograph reduces the amplifier complexity in the connection and control box. The Mark 220 is issued with chart speeds of 1 mm/sec, 5 mm/sec, 25 mm/sec, and 125 mm/sec. The gear box is not enclosed so that gear conversion is not difficult. The dimensions of gears to be replaced have not been determined at this time. The manufacturer should be consulted concerning desired chart speeds prior to contract negotiations.

4–6. Radio Receivers

The issue radio receiver is adequate for receiving radio time signals but should be replaced by another receiver if possible. Most receivers with a frequency range from 5 to 20 megahertz (MH_z) are suitable.

a. The issued 390A/URR model receivers are very heavy, require a 110V, AC, power supply, and easily become misalined. Upon receipt and prior to use they should be "electronically alined" by an electronic shop. Any time they receive a severe shock or seem to function improperly the electronic alinement should be checked.

b. The AN/GRC–87 provides a suitable time signal receiver with the added convenience of a transmitter, and should be considered when communications are necessary. The RT–77 is limited by having a frequency range no higher than $12MH_z$ and by not having a variable bandwidth control.

c. It is planned that the receiver, radio, time signal, MIL Spec R–52563, Amd 1, will be introduced into the set in the near future. This receiver is transistorized, battery operated, and crystal controlled. Until the unit is included in the supply system it must be purchased from the manufacturer.

d. Many new types of receivers are currently being developed by commercial enterprises; hence, the receiver to be used is a matter of preference and availability. The only requirements are the ability to receive the desired time signals, weight, and power usage.

e. One thing that must be considered in any receiver is the impedance of the audio output. The 390A/VRR receiver has an output impedance of 600 Ω and the MIL Spec R–52563 has an output impedance of 100 Ω. The output impedance of other type receivers must be determined by the user. The BL–222 and RD 2322–00 oscillographs

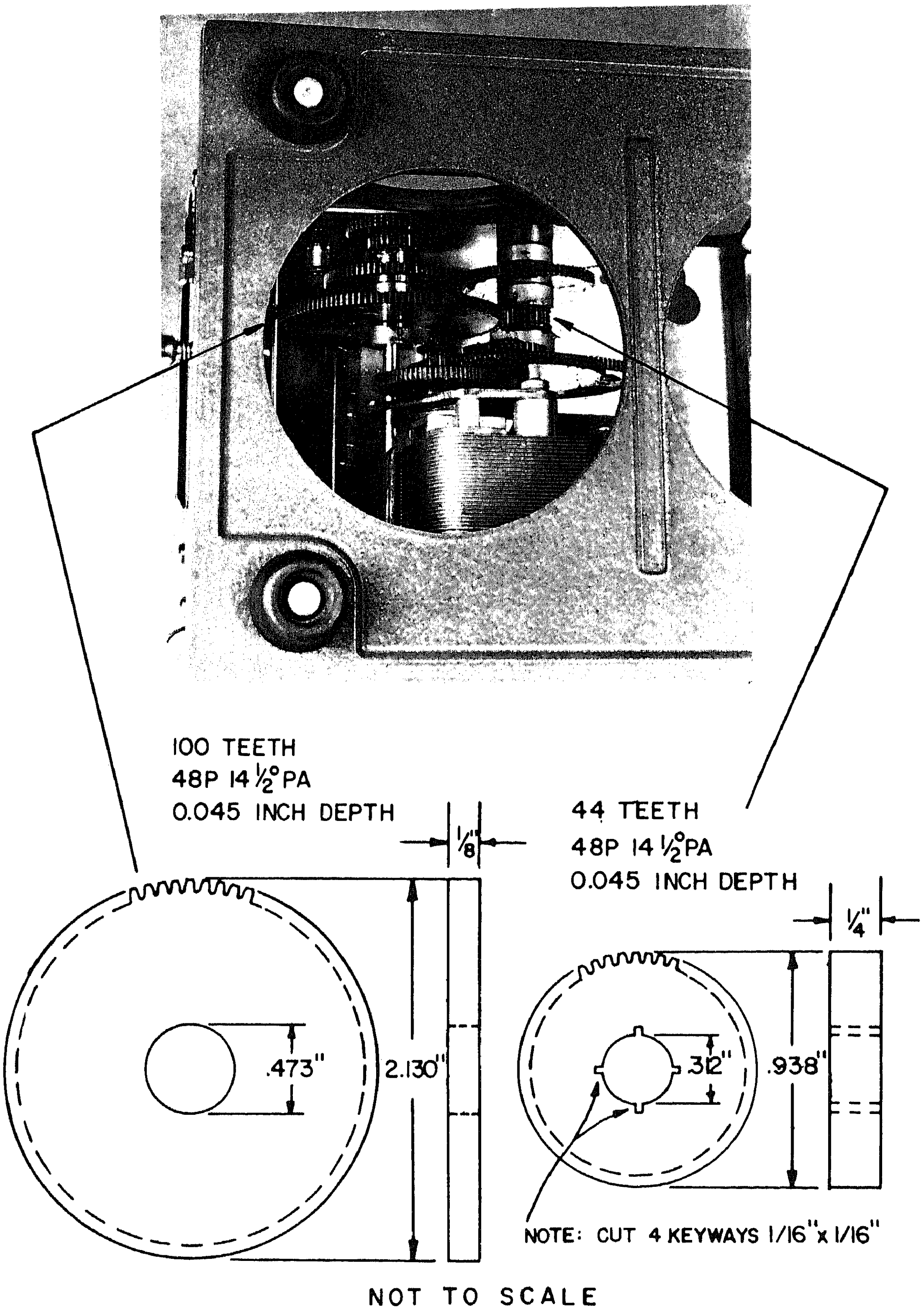


Figure 4-3. Brush oscillograph gear changes.

have an input impedance of about 1400 Ω and the MK220 oscillograph has an input impedance range of 0 to 10,000 Ω. Hence, an impedance matching transformer is included in the connection and control box and this transformer must be connected for the correct audio input impedance.

4-7. Antennas

Although any piece of wire will work as an antenna, a properly constructed and oriented antenna greatly improves reception. In areas of poor reception a proper antenna is necessary.

a. The length of antenna wire needed to properly receive a particular frequency is determined from—

$$\text{Length of antenna in feet} = \frac{468}{\text{frequency in } MH_z}$$

Hence, for a 10 MH_z frequency an antenna length of 46.8 feet is required. As harmonics of the basic frequency are also usable the same antenna is suitable for a 2.5 MH_z, 5 MH_z, and 20 MH_z frequency.

b. The antenna length determined from the above formula is the total length, including the lead-in, if an unshielded lead-in is used. Preferably a shielded lead-in should be used and the length computed is then the unshielded length. A shielded lead-in is constructed from coaxial cable. If special coaxial cable is not available, single or double lead shielded microphone cable is an excellent substitute. If double lead wire is used, only one of the leads is used and the other cut off at the end of the shield. When a shielded lead-in is used, it should be short in length.

c. There are many designs of antennas which may be used. However, only four are considered of significance in the field.

(1) *The Lazy-L.* This antenna, shown in *a*, figure 4–4, is used for unshielded lead-in antennas.

(2) *The vertical.* The antenna may be suspended in a vertical position by hanging it from a tall tree, etc. This antenna is not recommended as it is omnidirectional.

(3) *The long line.* This antenna, shown in *b*, figure 4–4, is the same as the lazy-L except that a shielded lead-in is used.

(4) *The doublet.* When a receiver has a double antenna connection, either two posts or a coaxial connector, the doublet (*c*, fig. 4–4) should be used. The lead-ins should be shielded. Unshielded lead-ins may be used but they must not touch each other. The antenna lengths may each be ¼ wavelength or ½ wavelength. If the lead-ins are not shielded the lead-in length is included.

d. With any antenna, the location should be clear and away from obstructions, especially metal structures. Any antenna, other than the vertical type which is omni-directional, must be oriented properly. This is especially true when the shielded lead-in is used. The greatest directivity of an antenna is perpendicular to the axis of the wide and the least sensitive position is parallel to the axis. The azimuth to the desired transmitter should be determined and the antenna set up perpendicular to that azimuth (fig. 4-5). When another transmitter is interfering with the desired transmitter, one end of the antenna should be pointed at the interfering station to reduce its effect.

4–8. Audio Filter

a. Most scientific time signal transmitting stations broadcast on the same radio frequencies and as can be expected many problems arise from receiving two or more stations simultaneously. An aid to overcoming this problem is that some major transmitters broadcast the actual time signals at different audio frequencies. The WWV time signal is broadcast at 1000 hertz (h_z), the WWVH signal at 1200 h_z, and the JJY signal at 1600 h_z. A 1000 h_z band-pass filter is presently included in the set but it is usable only for station WWV or other stations having similar characteristics. The connection and control box schematic in appendix E include provisions for an electronic filter that may be assembled to operate on any desired frequency.

b. As there is a possibility that more than one transmitter may be using the same audio frequency it is necessary that an unfiltered identification of radio signals be made. Since transmission delay is proportional to the distance from the transmitter, positive identification of transmitters can be made from an unfiltered recording of all the stations that may be received on the selected radio frequency. After the positive identification has been made from an unfiltered signal, the filter may be used to eliminate the extraneous noise and those transmitters using other than the desired audio frequency.

4–9. Amplifier and Connection/Control Box (Astroamplifier)

These two units are usually incorporated into a single unit and also include the audio filter. The complete unit is usually called the astroamplifier and unless otherwise specified this term will be used throughout the text. Components in addition to the parts issued with the equipment set must be procured to assemble an astroamplifier.

a. Functions. The astroamplifier serves several functions.

(1) The radio signals have a low potential at the output jack of the receiver, especially with the transistorized receivers. This potential must be amplified in order to provide sufficient power to operate the chronograph coil. A potentiometer is also included for controlling the strength of the current.

(2) The chronometer break circuit and the micrometer eyepiece are switches and do not have an internal power source. The astroamplifier provides this power source.

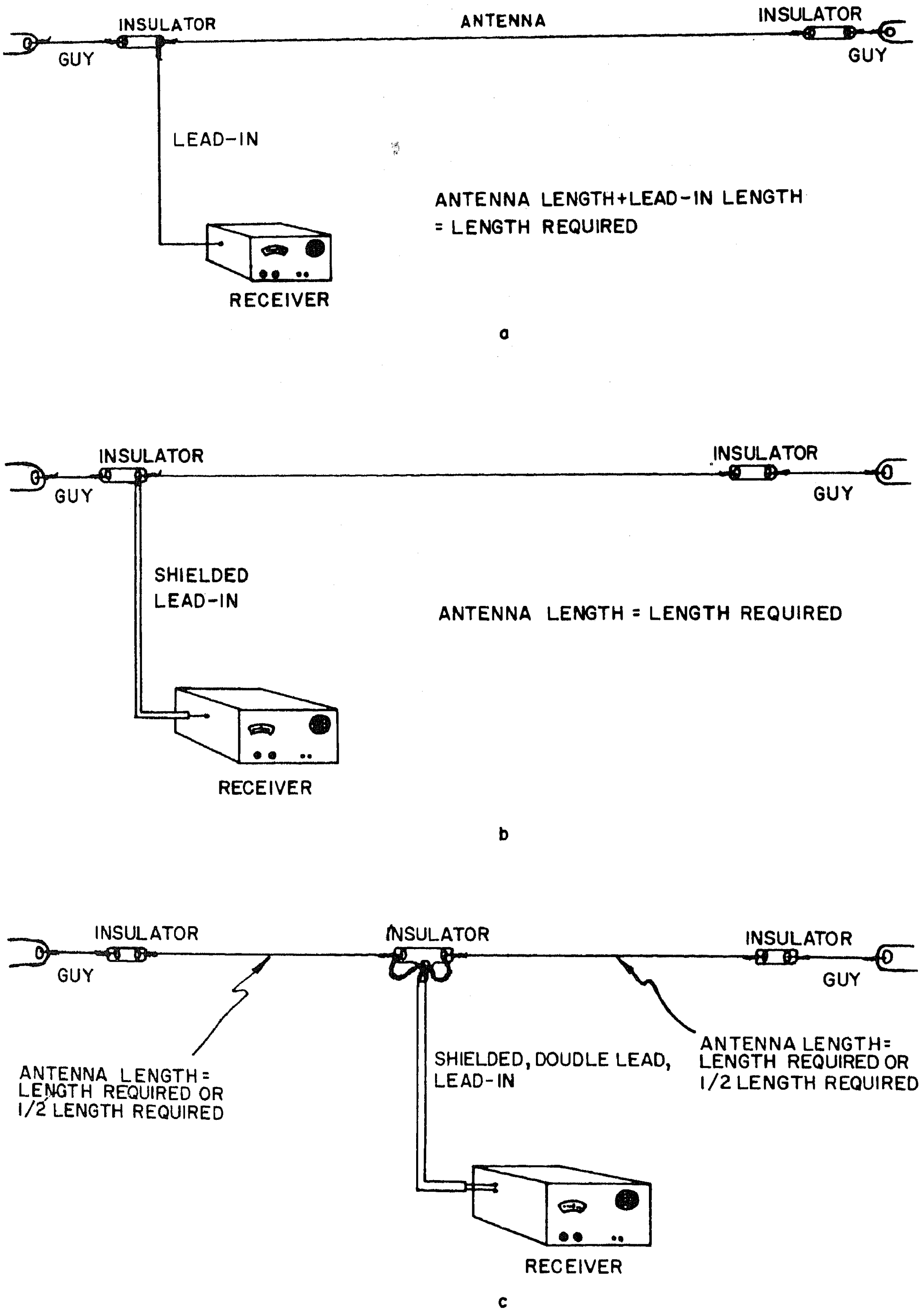


Figure 4–4. Antenna configurations.

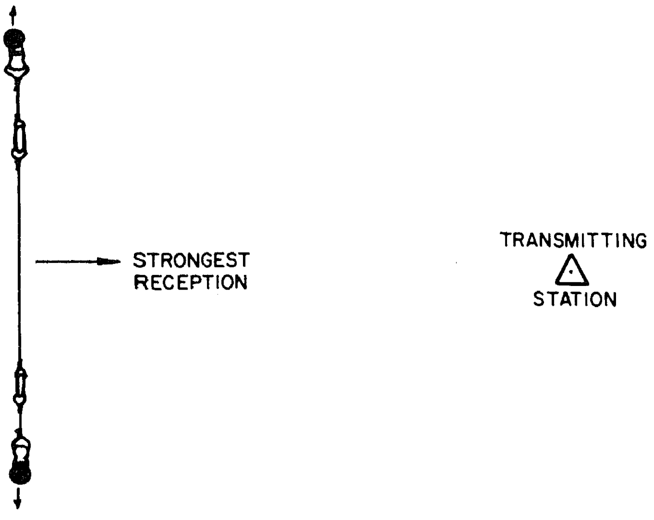


Figure 4–5. Antenna orientation.

NOTE

The power from the astroamplifier through the chronometer and the eyepiece micrometer must be of low voltage (6–12V) and the *current must be limited to 0.01* amp or less to protect the contacts.

(3) The chronometer records continuously whereas the radio and eyepiece micrometer do not. The astroamplifier provides for switching between these two functions.

(4) Neither the chronometer and radio nor chronometer and eyepiece micrometer can be directly wired together and connected to the chronograph coil. It is possible to connect the chronometer to one coil and either the radio or the eyepiece micrometer to the other. This is not usually done in practice as scaling the chronograph record becomes exceedingly tedious and error prone. The astroamplifier provides a mixing circuit to allow all three signals to be recorded with one chronograph coil.

(5) The audio output from the receiver is filtered to get rid of atmospheric noise and unwanted portions of the time signal. The output after the filtering is then amplified for use on the chronograph. (A schematic and list of materials for the astroamplifier are included in appendix E.)

b. Differential Lag.

(1) A finite amount of time is required for the radio signal to be processed through the receiver, amplifier, and audio filter. As the chronometer and eyepiece micrometer signals do not pass through the audio filter components, this time delay is commonly called "audio lag" or "lag in the audio filter" (fig. 4–6).

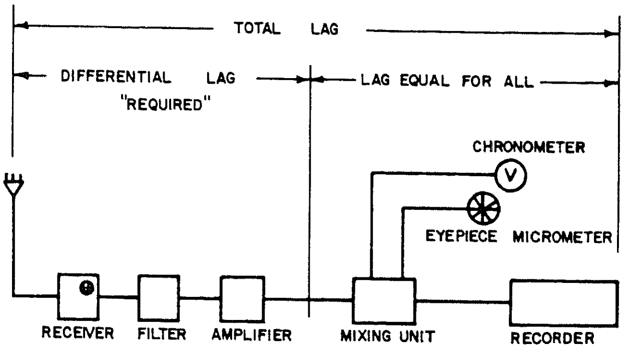


Figure 4–6. Differential lag block diagram.

(2) The determination of audio lag is not difficult but does require the facilities of an electronic laboratory or repair shop. A signal generator, a two channel oscilloscope and various other electronic components are needed for the determination. Because of the electronic equipment needed for this determination it is generally not within the capability of the field astronomic party.

(3) The method used for this determination is explained in general terms in (4) below for reference. A complete explanation of the methods used and the equipment needed for this determination can be received from the U.S. Army Topographic Command, 6500 Brooks Lane, Washington, D.C., 20315, upon request.

(4) The signal generator must be able to deliver a 1,000 h_z pulse on a 5–MH_z carrier wave. A direct connection from the signal generator is made to one channel of the oscilloscope. The other channel is similarly connected, with the exception that the radio and audio filter are included in this circuit. With the 5–MH_z carrier wave being broadcast by the signal generator the 1,000 h_z pulse is placed intermittently on the carrier wave. Correct interpolation on the oscilloscope will show how much time is required for the 1,000 h_z pulse to pass through the radio and filter. The lag is usually small; for the type of equipment described in this manual, the audio lag will usually be less than 0.001 second.

4–10. Power Sources

a. Voltage requirements for the battery-operated equipment are rather well established. If a special type battery is used, provision should be made for operation from a commercial dry cell if possible. Flashlight batteries, 1½-volt dry cells, and 6-volt "hot shot" dry cells can be purchased almost anywhere in the world.

b. A 110V, AC, 50/60-hertz/generator is required to power the Brush oscillograph and chart takeup and the radio receivers of the astro sets.

The generator should have a capacity of 250 watts minimum. Ideally, it should not be larger than 500 watts, as a large generator becomes a transportation problem. If immediate and complete military maintenance facilities are not available a commercial generator, common to the local area, should be procured.

4-11. Required Equipment

The basic complement of equipment required to perform a first-order astronomic observation is issued as Surveying Set, Astronomic Position, FSN 6675-641-8897 and is listed and described in SC 6675-93-CL-E34. The following is a list of equipment not included in the set that is essential to the performance of the work. Also included in this list is information regarding later model equipment which streamlines and modernizes the operation.

FSN or Source	*Item and Comment*	*Unit*	*Qua*
6660-664-4675	ALTIMETER-BAROMETER, ANEROID: 16,000 ft. altitude; w/carrying case FED . . . GG-B-116a, Amd 2, type 1, class 3	ea	1
Appendix E	AMPLIFIER, Astronimic	ea	1
Text (para 4-7)	ANTENNA, Radio	ea	1
6675-377-0655	BATTERY POWER SUPPLY: w/connector cord and plugs; MIL-C-11347C	ea	2
	BOOK:		
	General Catalogue of 33342 Stars for 1950.0; 5 volumes; by Benjamin Boss; Carnegie Institution of Washington; Johnson Reprint Corp.	se	1
7610-252-9407	Logarithmic Tables of Numbers and Trigonometric Functions; Baron Von Vega, author: D Van Nostrand Co. Inc.	ea	1
7610-634-6081	Practical Astronomy; hard cover; by J. J. Nassau; latest yr and edition; McGraw-Hill Publishing Co.	ea	1
6650-930-3835	BINOCULAR; w/carrying case, type M-20	ea	1
6145-542-6092	CABLE, RADIO FREQUENCY: RG-58 MIL C-17/28A type RG-58C/U	ft	500
7420-989-1610	CALCULATING MACHINE: non-listing hand, columnar, 8 keyboard	ea	2
As required	CHART, RECORDING: double channel ink recording	rl	24
6645-840-1391	CHRONOMETER, MAKE-BREAK CIRCUIT: rated for sidereal time; size 85 w/carrying case; (only one included in set) MIL-C-10724	ea	1
6605-846-7618	COMPASS, Magnetic, Surveyor's	ea	1
6145-188-3655	CORD, LAMP: type ST-1, parallel double conductor, #18, 250 ft spool	ft	250
5110-293-1910	DIE SET, METAL STAMPING, HAND: gothic; w/case; FED . . . GGG-D-280b, Amb 1 type I and II	se	1
As required	DRIVE, CHART TAKE-UP:	ea	1
6230-264-8261	FLASHLIGHT: MIL-F-3747A, Amd 3, Type I style 2, size 2 cell	ea	5
As required	INK, RECORDING INSTRUMENT:	ea	2
5970-503-0174	INSULATION TAPE, ELECTRICAL: plastic MIL-I-7798A, Amd 2	rl	1
5210-223-9606	LEVEL, LINE: 3 in. lg; FED . . . GGG-L-211b, type V	ea	1
5985-257-2927	MAST: antenna assembly; AB-86/GRA4	ea	2
6625-270-3775	MULTIMETER: 0 to 750 vac in 5 steps 0 to 750 vac in 5 5 steps, 0 to 150 ma in 3 steps; w/carrying case Simpson Model 260m or equal	ea	1
As appropriate	OSCILLOGRAPH: 2 recording channel	ea	1
As required	PEN, INKING: (for Oscillograph)	ea	6
5110-222-2708	PLIERS: Diagonal Cutting. 7½ in.; FED . . . GGG-P-00471d, Type IV, class 1, style B	ea	1
5120-278-0333	PLIERS: Slip Joint: straight thin nose; Combination w/cutter FED . . . GGG-P-00471d, Type II, class 2, style B	ea	1
	RECEIVER, RADIO: time signal; AM and MCW reception; 2.5, 5, 10, 15, 20, & 7.335 MH$_z$; audio output filters of 600, 1,000, 1,200, and 1,600 h$_z$; transistorized; battery operated, 7 size "C" 1.25 v nicad batteries w/charger; Specific Products Bulletin 360 C, model WWVT, WWV receiver, Mark II (modified for above frequencies and output); MIL-R-52563, Amd 1	ea	1
5120-234-8910	SCREWDRIVER, FLAT TIP: 6 in lg blade; FED . . . GGG-S-121d, Amd 5, type I, class 5, style 1, design A, shape A	ea	1
3439-243-1882	SOLDER, LEAD ALLOY: Wire; Rosincored; ⅛ in dia; 1 lb spool; FED . . . QQ-S-571d, composition SN-40 type WR, Core D 3 or P 3	ea	1
3439-588-1007	SOLDERING IRON: NON-ELECTRIC: with/ 1 ea COPPER TIP, ⅛ in 3432-588-1008 1 ea COPPER TIP, ¼ in	ea	1

FSN or Source	*Item and Comment*	*Unit*	*Qua*
3439–588–1007 Continued	3432–588–1009 1 ea COPPER TIP, ⅜ in 3432–588–1010 1 ea BRUSH 7920–577–4057 12 ea PRIMER CARTRIDGE 3439–711–0524 MIL–S–45864A		
As required	SYRINGE, PEN CLEANING AND INKING SET: BL–929	se	1
8340–634–0087	TENT: observing, astronomic MIL–T–40031B	ea	2
8340–292–9353	TENT: observing; triangulation ground type MIL–T–40001B	ea	1
6675–382–9140	THEODOLITE, SURVEYING (T–3): 24, 30, 40, dia porm 5 pct magnifying power of telescope w/3 eyepieces; elec illumination; w/accessories, carrier, cases, tools and fixed-leg tripod; Wild Heerbrugg Instruments Inc., MIL–T–52035A Type II	ea	1
6675–641–3572	TRIPOD, SURVEYING: head, ⅝ in –11 thd size binding screw; extension legs, wood 62 in porm 3 in lg, extending, 38 in porm 2 in lg retracted; metal tipped ft; carrying sling; MIL–T–14091B	ea	1
6675–NSN	⅝ in –11 thd size binding screw; 7⅞ in dia; for theodolite Wild T–3; MIL–T–11362C, size II	ea	1

Spare level vials, screws, and plugs should be available for onsite repair of broken parts on the instruments and equipment. When possible, a spare radio, generator, and astroamplifier should be included.

CHAPTER 5

PREPARATION FOR OBSERVATION

5–1. Preparation of the Astronomic Observation Site

a. Procedures for setting up the instrument are fully discussed in chapter 2. The stand or pier should be at such a height that when the observer is seated he is able to look through the telescope eyepiece comfortably without having to stretch his neck, but not so low that he will have difficulty in using the horizontal circle reading microscope. For the average man this requires that the top of the stand be about 24 to 30 inches above the ground.

b. Whenever feasible the instrument should be supported on a concrete pier. To keep eccentricity to a minimum, the pier should be set as near the station mark as practicable. A concrete pier is constructed in the following manner:

(1) Dig a hole 15 inches square to a depth of 36 inches, or more in loose sand or soft soil. If a firm footing (clay or bedrock) is encountered at a depth of less than 36 inches the surface should be gouged to provide a firm bond.

(2) Construct a plywood form, 15 inches square and 36 inches high. Place it over the hole in an approximate N-S-E-W position. The form should be wrapped with rope or wire to prevent its coming apart and braced on all four sides to prevent its tipping over. The inside of the form should be heavily oiled or lightly greased to facilitate removal after the concrete has set.

(3) Fill the hole and form with a mixture of 1–2–3 concrete. A minimum amount of water affording a workable mixture should be used and the concrete thoroughly tamped into place. The tamping should be done as the concrete is poured at 1-foot increments and continued until no large bubbles rise to the surface.

(4) The form should be filled to a level 24 to 30 inches above ground, depending upon the height of the observer. The top of the pier should be level and smooth. Depending upon the climate and moisture content of the concrete the pier will be ready for use in about 24 hours.

(5) Construction of a pier of the above dimensions requires about the following cubic feet of materials: cement, 2 1/3; sand, 4 2/3; and gravel, 7. About 10 gallons of water are required. When it is necessary to use sea water, the amount of cement should be doubled.

c. A walkway at least 12 inches wide or a platform *must* be placed around the stand or pier and so braced that the support is at least 3 feet away from the stand. The chairs or boxes that the observer uses should also rest upon this platform. The height to the top of the pier would then be measured from the platform. Although a walkway is adequate the construction of a portable platform is often more desirable. The platform may be disassembled and carried between astronomic stations. It is not only easier to emplace than a walkway but the underside of it may be used to mix concrete.

d. A transportable platform is constructed as follows:

(1) *Materials.*

(*a*) 2″ × 4″ × 6′—6 each wooden boards
(*b*) ⅜″ plywood 28″ × 72″—2 each
(*c*) ⅜″ plywood 16″ × 28″—2 each
(*d*) ½″ diameter × 4″ lag bolts—16 each
(*e*) 6d common nails—100 each

(2) *Construction.* The platform is constructed as shown in figure 5–1. Before screwing in the lag bolts drill shank depth with ½″ diameter drill and full depth with ⅜″ or 7/16″ diameter drill. Oil the underside of the platform before mixing concrete on it.

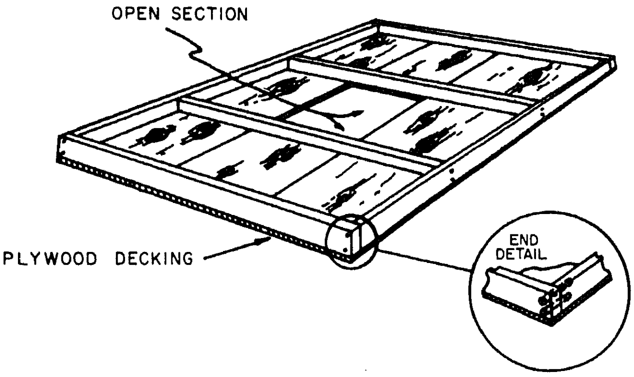


Figure 5–1. Portable platform (bottom view).

e. A table should be provided to hold timing equipment and for the use of the recorder. The chronometer must be carefully placed on a solid surface or support where it will not be disturbed but may be easily read by the recorder. When the arrangement is compact the equipment and recorder may be inside the astronomic tent with the observer; however, care must be taken to see that no light interferes with the observer. It is usually best if the recorder is situated outside of the observing tent. A hex-tent or triangulation observing tent provides an excellent shelter for the recorder.

f. Any heat that is provided for warmth must not interfere with the observations. A heater should never be placed inside the astronomic tent.

g. The astronomic tent which is provided in the astronomic position set is quite satisfactory for the observations. The gable end plates of the tent frame are easily broken and it is best if the issue plates are replaced immediately with plates made from ¾-inch plywood. The specifications for the tent and the procedure for erecting it will not be given here. The observing slot must of course be alined with the meridian, and to accomplish this the magnetic compass usually gives the direction of the meridian with sufficient accuracy. The tent should be well guyed so that it will not flap in the wind. A sod cloth is provided at the bottom and should be used to provide a seal around the tent. In windy areas a wind screen should be erected about 3 to 5 feet to the windward side of the tent. This wind screen should be used with caution in desert areas, as a vortex effect may cause sand or dust to be picked up and blown into the observer's eyes.

h. Tarpaulins spread on the ground inside the tent help to keep the dust down. In extremely cold or windy areas it may be desirable that a portable plywood observatory be constructed. With this type of observatory it is possible to make the observation slot adjustable so that it may be narrowed to a small slit after the instrument is oriented in the meridian, but precautions must be taken to prevent heat waves from affecting the observation. Even body heat from the observer may cause heat waves.

5–2. Basic Position Data

Before precise determination can begin with the T–4 the position of the station should be known within 5′ of arc. The initial position is used in making observing lists and a 5′ error is insignificant, except for Horrebow-Talcott latitude observations where it is best if the latitude is known within 2′ of arc. When the astronomic work is being done in connection with triangulation the geodetic location is used as the assumed position If there is no triangulation station at the astronomic station the position can usually be scaled with sufficient accuracy from an existing map. In desolate areas where the maps are unreliable or nonexistent it is necessary to observe a preliminary astronomic position. Although a T–2 or T–3 may be employed, the T–4 itself can be used for the observation of an initial position.

a. Latitude by Table II, AE&NA. When Polaris is visible the latitude may be most readily obtained by the following method.

(1) Using the assumed longitude start the chronometer and determine the chronometer correction (para. 6–14). Observe the zenith distanc of Polaris direct and reverse, recording the chronometer time of each observation. Determine th mean zenith distance and mean corrected chronometer time.

(2) Using the corrected chronometer time interpolate the values of a_0, a_1, and a_2 from table II in the appropriate American Ephemeris and Nautical Almanac, TM 5–236–Yr. Compute the refraction correction, r, from: $r = 60''.6 \tan \zeta$ and the corrected altitude from: $h = 90^\circ - (\zeta + r)$. The corrections to refraction for temperature and pressure are not required. Compute the latitude (ϕ) from: $\phi = h + (a_0 + a_1 + a_2)$.

(3) The latitude determined from this method will be in error to a certain extent because of the error in the assumed longitude. However, if this error in assumed longitude does not exceed abou 1 minute of time the effect on the initial latitude is not significant.

b. Latitude from the Meridian Zenith Distanc of Any Star. When Polaris is not visible or is at a very low altitude another method of finding th initial latitude must be used.

(1) When the right ascension of a star and the local sidereal time are equal, the star will b on the local meridian and also at its greatest altitude. By determining the zenith distance of a sta on the meridian the latitude can be determined from: $\phi = \delta \pm \zeta$.

(2) Using the assumed longitude, start th chronometer and determine the chronometer correction (para. 6–14). From the Apparent Place of Fundamental Stars (APFS) find a star tha will be on the meridian in 5 to 10 minutes. Determine the chronometer reading for the time o transit from the star's right ascension + chronometer correction ($\alpha + \Delta T$). Locate the star in th telescope and track it with the 10 wire in azimuth and altitude. At the determined chronometer tim

racking and determine the zenith distance direct position, circle left.

3) Correct the observed zenith distance for refraction and compute the latitude from $\pm \zeta$. This is the general formula and algesigns are important (para. 6–6).

4) This method of determining latitude is t to errors owing to the star actually not on the meridian and vertical collimation er- the time the zenith distance is measured. eridian error is of no significance in deterg an initial position. Vertical collimation erin be reduced by adjustment of the vertical . Both a star north of the zenith and a star of the zenith should be observed in the same position (left or right) and a mean latitude these values used.

ongitude. Of the many methods of determin- initial longitude, the most expeditious with –4 is that of the transit of stars over a great approximating the meridian. The procedures sentially the same as those used when placle instrument in meridian (para. 5–4).

(1) Rather than determine the azimuth of the instrument (a), the chronometer correction is determined and used to correct the assumed longitude.

(*a*) Using the assumed longitude start the chronometer and determine the chronometer correction (para. 6–14). Using the procedure in paragraph 5–4, observe the chronometer time of transit of both a north and south star. The azimuth factors, A, for each star should be less than 1.0.

(*b*) Determine $(\alpha - t)$ for each star from the star's right ascension minus chronometer time, and the azimuth factor for each stár from table B–1, appendix B.

(2) An equation in the form $\Delta T + Aa - (\alpha - t) = 0$ is written for each star and the equations solved for ΔT. Applying ΔT to the chronometer time of a radio signal gives the local sidereal time and subtracting the local sidereal time of the signal from the Greenwich sidereal time of the signal results in the station longitude. As an example:

16 May 1968 PM

South Star #1422, $A = +0.54$

$$\begin{array}{rrr} \alpha = 16^h & 07^m & 38^s\!.6 \\ t = 16 & 07 & 28.0 \\ \hline \alpha - t = & & +10.6 \end{array}$$

North star; $\Delta T - 0.48a - 10.4 = 0$
South star; $\Delta T + 0.54a - 10.6 = 0$

Multiplying each equation by the A factor of the other equation:

$$\begin{array}{lrrr} (N) & +0.54\,\Delta T & -0.2592a & -5^s\!.616 = 0 \\ (S) & -0.48\,\Delta T & -0.2592a & +5.088 = 0 \end{array}$$

Changing the sign of the South star equation:

$$\begin{array}{lrrr} (N) & +0.54\,\Delta T & -0.2592a & -5^s\!.616 = 0 \\ (S) & +0.48\,\Delta T & +0.2592a & -5.088 = 0 \\ \hline (S) & +1.02\,\Delta T & & -10.704 = 0 \end{array}$$

$$\Delta T = 10^s\!.5$$

North Star #595, $A = -0.48$

$$\begin{array}{rrr} \alpha = 15^h & 56^m & 64^s\!.7 \\ t = 15 & 56 & 53.3 \\ \hline \alpha - t = & & +10.4 \end{array}$$

Chronometer time of signal (*CTS*):

$$\begin{array}{lrrr} CTS & 15^h & 51^m & 06^s\!.7 \\ \Delta T & & & +10.5 \\ \hline LST & 15 & 51 & 17.2 \\ & & & \\ WWV\quad UT & 05^h & 20^m & 00^s \\ STO^h\ 17\ \text{May} & 15 & 39 & 00.8 \\ \text{Gain} & & & 52.4 \\ \hline GST & 20 & 59 & 53.2 \\ LST & -15 & 51 & 17.2 \\ \hline \lambda & 5^h & 08^m & 36^s\!.0 \end{array}$$

(3) Errors in this observation may result dislevelment of the vertical axis and collima- If the instrument is well adjusted and careleveled these errors are insignificant.

Placing the Instrument Approximately in the Meridian

After the assumed position of the astronomic n has been adopted, the T–4 is placed in the of the observer's meridian; that is, when the al motion of the telescope is swung, an extenf the telescope axis (the line of sight) traces the observer's meridian. When the telescope's optical axis is pointed at the true astronomic north, and the instrument is leveled (the vertical axis thereby pointing at the zenith and nadir), the instrument is in the meridian.

b. The easiest method of placing the instrument approximately in the meridian is setting up on a triangulation station with a known azimuth. Point the telescope on the azimuth mark, set the horizontal circle to the known azimuth, and move the telescope horizontally until the circle reads 0°. The azimuth of the instrument is now said to be 0° and in the meridian. This of course is not quite true, since the known azimuth is geodetic and not astronomic, but it is close enough for the initial orientation.

c. If no azimuth mark is available and the observer is at such latitude that Polaris is visible, he can place the T–4 approximately in the meridian by use of the proper tables in the AE&NA.

(1) Having the chronometer running at the assumed local sidereal time or knowing the chronometer correction (ΔT), the observer points the instrument on Polaris and tracks with the horizontal slow motion screw.

(2) When the star is well bisected the observer stops tracking and simultaneously calls "tip". The recorder notes the chronometer time.

(3) Entering table II of the AE&NA (TM 5–236–Yr), for the year of observation, the recorder determines the value of the coefficients; b_0 for the local sidereal time; b_1 for his latitude and the LST; and b_2 for the month of observation and the LST. The coefficients are added algebraically and the result is multiplied by the secant of the latitude (or divided by the cosine). The result is the azimuth of Polaris from north. When the sign is negative, Polaris is west of north; when positive, it is east of north. The azimuth of Polaris is set on the micrometer and horizontal circle before the telescope is disturbed.

d. When the position of the observer is such that Polaris is not visible the instrument may be oriented roughly with a compass and then placed approximately in the meridian with the following method:

(1) After the approximate local sidereal time has been determined a high magnitude (1 or 2) star about to transit is selected from the APFS. After the star is found in the telescope, the observer tracks it with the horizontal slow motion screw.

(2) The recorder, having determined what the chronometer will read when the right ascension of the star equals the local sidereal time, calls "tip" at the predetermined chronometer time. The observer stops tracking and the instrument should now be approximately in the meridian.

e. Upon completion of the approximate meridian placement the horizontal circle micrometer should be set at 00″ and then the horizontal circle set at 00° 00′ by use of the horizontal circle drive knob.

5–4. Determination of Telescope Orientation

All of the above methods place the instrument only approximately in the meridian. Since the azimuth error should be less than 1 second of time, other methods must be used to place the instrument more exactly in the meridian.

a. Stars with the same right ascension are on the same hour circle; consequently, they will be on the observer's meridian at the same time. If we could observe two stars (one north of the zenith, the other south) with the same right ascension and they both were to cross the wire approximating the meridian at the same time, we would know that the instrument was in meridian. If, however, one crosses before the other we would know that the instrument was not in the meridian (fig. 5–2).

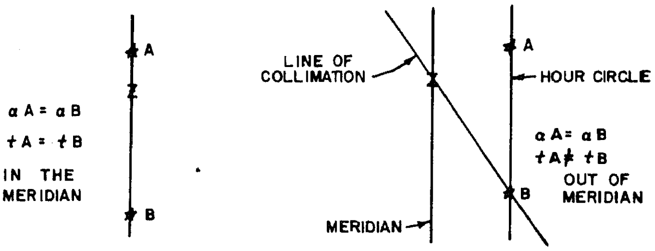


Figure 5–2. In or out of the meridian.

(1) Since we cannot observe a north and a south star at the same time and two stars seldom have the same right ascension, we relate their time of transit to the chronometer. If a north star "A" with "α" equal to $12^h\ 02^m\ 30^s$ transits (crosses the center wire) at a chronometer time (t) of $12^h\ 02^m\ 30^s$ and a south star "B" with "α" equal to $12^h\ 05^m\ 21^s$ transits at a chronometer time (t) of $12^h\ 05^m\ 21^s$ the value of "$(\alpha - t)$" of both is 0^s; therefore, the instrument is in the meridian.

(2) If star "A" transits at $12^h\ 02^m\ 33^s$ and star "B" transits at $12^h\ 05^m\ 24^s$, the value of "$(\alpha - t)$" in each case is minus 3^s. In this case the instrument is still in the meridian but there is an error in the local sidereal time, either from the assumed longitude or in the chronometer setting.

(3) However, if the transit times are respectively $12^h\ 02^m\ 33^s$ and $12^h\ 05^m\ 18^s$, the values of "$(\alpha - t)$" are respectively, -3^s and $+3^s$, and the instrument is not in the meridian. The value of 3^s cannot be multiplied by 15 (for conversion to arc) to obtain the proper correction. Inasmuch as time differences (in a sense of angular value) are measured along the equator and the circle of the instrument measures angles in the plane of the horizon we must have a correction for the observer's latitude.

b. It is easily visualized that even though the angular difference of two hour circles at the equator is, say, 1^s (15″), these hour circles converging at the pole make the angle variable when measured in different planes; the stars nearer the poles appear to be closer to each other in an angular sense than those nearer the equator (fig. 5-3). The factor for reduction is given by the following expression:

Azimuth factor (A)

$$= \sin \zeta \sec \delta = \sin \phi - \tan \delta \cos \phi$$

Where:

ζ = zenith distance of the star
ϕ = latitude of observer
δ = declination of the star

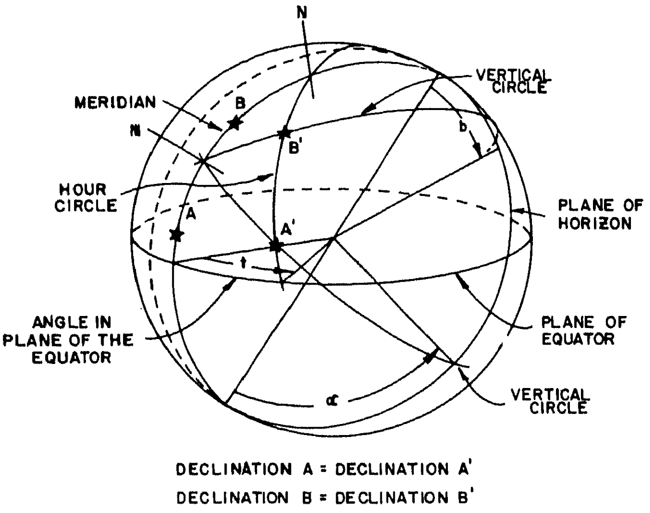


Figure 5-3. Angular variation owing to difference in latitude.

c. All stars between the zenith and the north pole have a negative (—) "A" factor. Subpolar stars in southern latitudes also have a negative "A" factor. (For lower transits use 180° — δ instead of δ). Table B-1, appendix B, contains "A" factors that will give sufficient accuracy for placing the instrument in the meridian.

d. We may write an equation for the transit of each star, as follows (Mayers Formula).

$$\Delta T + Aa + Bb + Cc - (\alpha - t) = 0$$

Where:

ΔT = chronometer error
A = azimuth factor
a = azimuth error (east or west of north)
Bb = level correction in seconds of time
Cc = collimation correction in seconds of time
$(\alpha - t)$ = star's right ascension minus time of observation

If the instrument has been carefully leveled and adjusted the terms "Bb" and "Cc" may be ignored, leaving two unknowns: "ΔT" and "a". By subtracting the equation for a north star from the equation for a south star the terms "ΔT" cancel. By solving the equation for "a" and multiplying by 15 we obtain the azimuth error directly in seconds of arc in the horizon.

e. As an example:

For a south star,

$$A = +0.53 \text{ and } (\alpha - t) = +17{:}5$$

For a north star,

$$A = -0.66 \text{ and } (\alpha - t) = +2{:}8$$

The equations are:

$$\text{South star, } \Delta T + 0.53a - 17{:}5 = 0$$
$$\text{North star, } \Delta T - 0.66a - 2{:}8 = 0$$

Subtract the equation for the north star from that for the south by changing the signs for the north star and adding algebraically, thus:

$$\begin{array}{ll} +\Delta T + 0.53a - 17.5 = 0 & \\ \underline{-\Delta T + 0.66a + 2.8 = 0} & \text{(signs changed)} \\ +1.19a - 14.7 = 0 & \text{(algebraic addition)} \\ +1.19a = +14.7 & \\ a = +12{:}4 = (12.4)(15) & \\ = +186'' = 03'\,06'' & \end{array}$$

If the sign of "a" is positive (+) the telescope, when pointing northward, is to the west of the meridian; if negative (—), the telescope is east of the meridian. A simple sketch verifies the misorientation of the telescope. The summation of the "A" factors of the stars used in putting the instrument in the meridian must be greater than 1.

f. The placement of the instrument in the meridian precedes any observation and should be checked closely. If in doubt, check. If the instrument is releveled during the night's observation, placement in the meridian must be rechecked. The azimuth error should not exceed ± 1' (15"), and must never exceed ± 3' (45").

5-5. Procedure for Placing the Instrument in the Meridian

a. After the instrument has been placed approximately in the meridian, a north star and a south star, with an "A" factor summation greater than 1, are taken from the APFS. The time between the transit of the selected stars is dependent upon the observer's speed, with 5 minutes being about the average. The zenith distances are computed and the circle setting determined for the position of the ocular used. With the instrument set for the first star, the observer calls "tip" as the star crosses the center wire and the time is recorded. The same procedure is used for the second star.

b. The formula for "a" is solved and the direction is determined. The following examples provide detailed instructions. The process, although not difficult, must be carefully accomplished. If not done properly a full night's work may be lost. Assuming the horizontal plate and micrometer were set and still read 00° 00′ 00″.0, then if:

(1) The instrument was oriented 25″ east of north

(*a*) Set 25″ on the coincidence micrometer.

(*b*) Bring the horizontal circle back into coincidence with the circle setting knob.

(*c*) Set the coincidence micrometer back to read zero.

(*d*) Move the horizontal circle back into coincidence with the horizontal slow motion screw.

(2) The instrument was oriented 25″ west of north

(*a*) Set 25″ on the coincidence micrometer.

(*b*) Bring the horizontal circle back in coincidence with the horizontal slow motion screw.

(*c*) Set the coincidence micrometer back to read zero.

(*d*) Move the horizontal circle back into coincidence with the circle setting knob.

(3) The instrument was oriented 1′ 10″ east of north

(*a*) Set 10″ with the coincidence micrometer.

(*b*) Set 1′ with the circle setting knob; being east it should read 00° 01′.

(*c*) Set the coincidence micrometer back to zero.

(*d*) With the horizontal slow motion screw bring the horizontal circle back into coincidence at 00° 00′.

(4) The instrument was oriented 1′ 10″ west of north

(*a*) Set 50″ with the coincidence micrometer.

(*b*) Set 2′ with the horizontal circle setting knob; being west it should read 359° 58′.

(*c*) Set the coincidence micrometer back to zero.

(*d*) With the horizontal slow motion screw bring the horizontal circle back into coincidence at 00° 00′.

c. This continues until "*a*" is less than 1′. When putting the instrument in the meridian the axis is not reversed; it remains in one ocular position east or west. After the instrument is in the meridian it should be checked in the opposite ocular position.

5-6. Station Eccentricity

a. If the astronomic position is observed eccentrically to the survey station, a diagram (fig. 5-4) certified by the party chief, showing the eccentric distance, horizontal direction or azimuth, magnetic bearing, elevation of the telescope, and height of the support above the ground level shall appear in the field records. Efforts should be made to keep the eccentric distance less than 30 meters and never more than 100 meters, unless approved by higher authority. Eccentricity of the azimuth station should be avoided if at all possible.

b. Where the eccentricity is less than 100 meters, the distance may be adequately determined by third order taping procedures. With the T-4 in the meridian and the horizontal circle properly oriented, the direction or azimuth may be found by pointing the telescope toward the true station and reading the horizontal circle, or the direction (azimuth) may be determined by conventional survey methods. When the direction (azimuth) is observed with the T-4, it should be done between sets of longitude observations.

c. The eccentric correction may be computed from:

$$\Delta\lambda = \frac{s \sin \alpha A'}{\cos \phi} \text{ and } \Delta\phi = -s \cos \alpha B$$

Where:

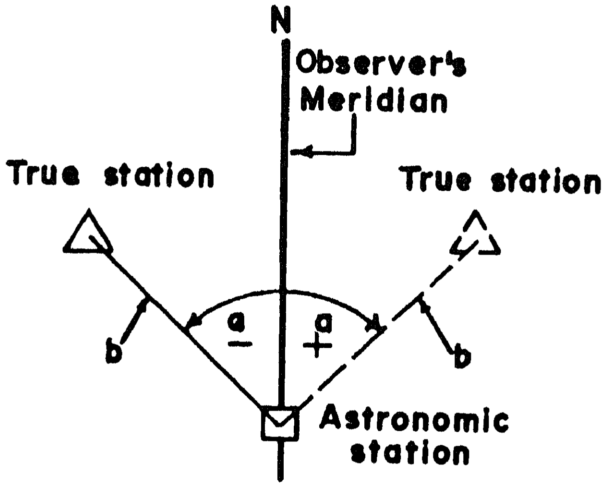
$\Delta\lambda$ = correction to longitude of astronomic station

$\Delta\phi$ = correction to latitude of astronomic station

s = eccentric distance

α = eccentric azimuth, from south, to the "true" station from the "eccentric" station

A′ and B are taken from TM 5-241-1 for the appropriate spheroid. The primed values indicate that the latitude of the forward station was used as the interpolating argument.



360° ± a = Az astro to true sta

a = angle obs with T-4 (minus west plus east)

b = distance astro to true sta

Figure 5-4. Eccentric astronomic station.

CHAPTER 6

DETERMINATION OF LONGITUDE

6–1. General

a. In the determination of astronomic longitude it must be understood that local time and local longitude are identical values expressed in different terms, and that the difference in the local mean times of two points is equal to the difference in their longitudes. Further, it is understood that longitude observations are accomplished with the instrument in the meridian and adjusted so that the line of sight defines the plane of the observer's meridian as the telescope is rotated about its horizontal axis.

b. Basically the longitude of a station is determined by assuming a station longitude, setting a chronometer to the local sidereal time for the assumed longitude and, with the instrument in the meridian, observing the chronometer times of star transits. Since the local sidereal time is equal to the right ascension of a star at upper transit, on the observer's meridian, the time correction to the assumed longitude is equal to the difference between the right ascension of the observed star minus its chronometer time of transit (fig. 6–1).

c. The chronometer is set to the local time for the assumed meridian by use of radio signals that are broadcast for the standard time of a known longitude.

6–2. Specifications (Low and Mid-Latitudes)

a. First Order.

(1) Only stars catalogued in the Apparent Places of Fundamental Stars (APFS) will be used.

(2) The "A" factor of any star observed shall not exceed ± 0.75, and should not exceed ± 0.60. The algebraic summation of the "A" factors in a set of star observations will not exceed ± 1.00. Further, the algebraic summation of the "A" factors for all sets observed should not exceed ± 1.00.

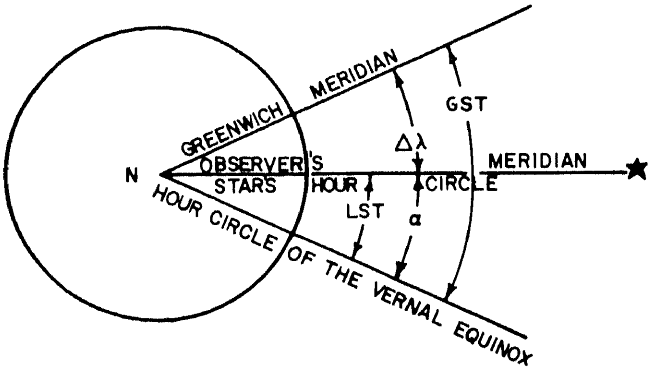


Figure 6–1. Longitude from time difference.

(3) A set of observations usually consists of six star transits with the time required for observing each set not normally exceeding 1 hour. Five star transits are the minimum acceptable for a single set. When an even number of stars make up a set, they should be evenly divided between north and south stars, i.e., 3N and 3S, or 4N and 4S. In sets with an odd number of stars, the number of north stars should not exceed the number of south stars, or vice versa, by more than one, i.e., 3N and 4S, or 3N and 2S.

(4) At least six individual sets of stars are observed for each station. At least two sets of stars are observed during any one observation period. The observation periods should be completed in two or more nights; however, they may be completed in one night if at least 4 hours separate each observing period.

(5) The stars observed should be tracked over a range sufficient to provide 20 but never less than 10 pairs of contact breaks on the chronograph record to determine the stars' transit time. Normally 25 to 30 contacts are recorded to satisfy this limit.

(6) In general, stars that are dimmer than 7.0 in magnitude are not observed. Stars with a magnitude too bright for proper bisection are reduced by a filter or screen over the telescope objective lens.

(7) When using a mechanical chronometer each set of observations is preceded and followed by a radio-chronometer comparison that contains no fewer than 20 scalable radio-time signals. A single common radio-chronometer comparison may follow one set and then be used to precede the next set. The radio signals must have been transmitted by a radio station of known position and the signal must be of such scientific quality that it is monitored by an observatory which publishes time signal corrections.

(8) The interval between comparisons should not exceed 1 hour and never exceed 2 hours if me-

chanical chronometers are used.

(9) In the computation of the individual sets, any star's residual (v) should not exceed $0^{s}.08$ sec ϕ, unless it is balanced by another residual of about equal amount and opposite sign. Any difference from the mean greater than $\pm 0^{s}.15$ sec ϕ causes rejection of that star.

(10) In the longitude summary, the residual of any set must not exceed 2.5 sec ϕ times the probable error of a single set, i.e., the rejection limit, $r = 2.5\, e_s$ sec ϕ. The probable error of a single set is computed from:

$$e_s = \pm 0.6745 \sqrt{\frac{[vv]}{n-1}},$$ where n is the number of stars in the set.

Hence, the probable error of the mean longitude $e\lambda$ is:

$$e\lambda = \frac{e_s}{\sqrt{n}},$$ where n is the number set in the determination.

(11) The indicated probable error of the mean result of first order longitude observations should not exceed $\pm 0''.10$ sec ϕ. Prior to clearing the station, sufficient computations will be made to satisfy these limits.

(12) If there is an indication that the probable error will be exceeded, an investigation of equipment, tracking, and scaling should be performed before resorting to additional observations.

b. Modified First Order. The methods, procedures, and specifications are the same for modified first order as first order except as noted.

(1) Three individual sets of stars are observed for each station. A set of stars usually consists of six star transits.

(2) The observations may be completed in one night.

(3) The indicated probable error of the mean result should not exceed $\pm 0''.30$.

6–3. Specifications (High Latitude)

a. The specifications in paragraph 6–2 are adhered to with the following exceptions.

b. Since north (south) stars are relatively scarce at high northern (southern) latitudes, it is permissible to include in any one set only one pair of stars consisting of a north star matched to a south, if each of the other pairs in the set meets one of the following conditions:

(1) Two south stars with an azimuth factor ratio of not less than 2 : 1.

(2) One south star, and one subpolar star.

c. Azimuth factors of the south stars must be well distributed in the range from 0 to 1. The subpolar azimuth factor must not exceed 2.5. In the
southern hemisphere the reverse procedur

d. Since level corrections become criti
using high declination stars, leveling pr
must be performed with the utmost care
forts should be made to have the algebr
mation of all the level inclinations appro
(0).

e. In high latitudes as in other area
world, three pairs of stars are equivale
set, meaning that eighteen pairs or six set
be observed. The more pairs observed du
one observation period, the better, but
mum number, as specified in paragraph
is required for higher latitudes.

6–4. General Instructions for Observati

a. The instrument is carefully adjus
placed in the meridian with an azimuth
less than 1 second of time before observa
gin. During observations, the hanging lev
ences, (W–E), should never exceed ± 10
and the summation of the level difference
longitude sets should approach zero (0).
strument is always kept well leveled, bu
releveled during a set of star transits. A
and negative inclination balance is mai
e.g., if one set is inclined positively, then
lowing set should be purposely inclined
negative direction.

b. Before observations begin an observa
is prepared. This list contains all availa
with consideration given to "A" factors a
ascension.

c. The adjustment of the instrument is
frequently. The roller bearings on the st
and the clear contact area (bearing pivots
trunnion axis are kept free of oil and dus
use. When not in use these parts are oiled
vent rust and corrosion. The micrometer
freely and smoothly in both directions.
tact strips of the micrometer are clea
quently to insure good electrical contact,
ably after each set. This is best accompli
holding a tissue or other material lightly
the micrometer contact strips and turni
both directions. The contact "Y" is best
by placing the cleaning material betw
points on the "Y" and drawing it slowl
from the drum.

d. The observations are *ALWAYS* prec
a radio-chronometer comparison when a
cal chronometer is used. It is very conveni
a great help in the final computations, if th
ometer is set as close as possible to the lo
real time.

e. The chronometer used for the comparison must be undisturbed for at least 3 hours prior to its use, and must not be disturbed during the observation period.

f. All time comparisons are recorded by means of a suitable radio receiver, amplifier, and chronograph. The comparisons are permanently recorded by means of a Brush oscillograph, or its equivalent, at a chart speed of approximately 25 mm/sec. The record must be clear and legible and sufficiently durable to withstand scaling. Pen and ink, hard wax, pressure sensitive, or heated stylus records are acceptable.

g. To provide for accurate identification of radio transmitters whose signals are received at the station, the chronograph is operated at approximately 125 mm/sec for a few seconds before and a few seconds after a full minute signal. Preferably the recording is during the start of a full 5-minute signal so that call signs are also recorded. The signal should not be filtered during the recording for identification.

h. With the instrument in either the ocular east or ocular west position, the recorder calls out to the observer the initial setting circle value for a star nearing transit. The observer sets this reading on the setting circle. He then levels the setting circle bubble by unclamping the telescope and moving it by hand, roughly leveling the bubble. He then clamps the scope and fine levels the bubble by means of the vertical slow motion screw. The recorder now calls out the explement of the initial circle setting and the observer resets the setting circle on this value, but *does not* at this time level the setting circle bubble by moving the telescope. This procedure enables the observer to relocate the star as quickly as possible upon reversal of the telescope. The recorder now informs the observer of the magnitude and approximate time until transit. A 2-minute warning before transit time should always be given to the observer by the recorder.

i. Before tracking commences the observer must move or position the movable wire outside the 5 or 15 wire (depending on ocular position) and check horizontal circle for a zero degree reading. Just prior to beginning actual tracking of star, the observer tells the recorder to turn on the chronograph (for tape type only, since the drum type runs continuously). The observer tracks the star slightly more than half way toward the center of the field of view (about 2½ turns) with the eyepiece micrometer. Without again touching the eyepiece micrometer he calls out the readings of the hanging level bubble ends, always west end first, to the recorder. The light must not shine directly on the level vial because heat from the light can cause the bubble to move. Since the observer's movement could cause a deflection of the bubble an assistant observer, when possible, should read the hanging level during observations.

j. The instrument is then reversed 180° and the telescope reset for the same star by merely leveling the setting circle bubble. When the star has moved to the movable crosshair, as left from tracking in the previous position of the telescope, the observer resumes tracking until the star has left the usable field of the telescope. The observer calls for the recorder to turn off the chronograph (tape type only) and then reads the bubble ends of the hanging level, west end first, to the recorder. Level readings are estimated to the nearest one tenth (0.1) graduation.

k. The instrument need not be reversed between stars as observations may begin in either the ocular east or ocular west position.

l. The recorder enters the star catalog number on the chronograph tape or drum at the start of each star observation. The minute marks from the chronometer should be identified on the tape as often as possible and each star should be bracketed by two such identifications. With the drum chronograph, time need be entered only three or four times per sheet if the drum is left running continuously. The level readings called by the observer are entered on DA Form 2844 (Longitude Record (Original Transit Level Readings)).

m. The chronograph should be operated at a speed of approximately 10 mm per second for star transits and approximately 25 mm per second for radio-chronometer comparisons.

6–5. Pen Equation Test

a. If the connection of the electrical timing equipment is such that the radio and eyepiece micrometer signals are not recorded on the same pen of the chronograph, a pen equation test must be made prior to and upon completion of a night's observations, and also when the pen or stylus has been changed or disturbed in its holder.

b. To make the pen equation test, disconnect the plug (plugs) that feed the signals into the chronograph and manually move the pens in the same direction to maximum deflection. Run about 2 inches of paper on the chronograph, stop the paper, and move the pens to maximum deflection in the opposite direction. Run about 2 more inches, stop. The mean scaled linear distance, radio channel mark to chronometer channel mark, converted to time units (allowing for the chart paper speed of the chronograph) is applied to each radio-chronometer comparison. Similarly, the mean scaled linear distance, T-4 channel mark to chronometer channel mark, converted to time differences, is applied to the mean scaled transit time of each star. The time difference of the two corrections may also be applied to the final observed longitude. The corrections must be carefully and judiciously determined and applied.

6-6. Use of the Setting Circle

a. The formulas for determining meridian zenith distances in the northern latitudes are—

(1) For stars with a declination greater than the observer's latitude: $\zeta = \delta - \phi$

(2) For stars with a declination less than the observer's latitude: $\zeta = \phi - \delta$

(3) For subpolars (stars at lower transit):

$\zeta = 180^\circ - (\phi + \delta)$

Where:

ζ = the meridian zenith distance
ϕ = the observer's latitude
δ = the star's declination

These equations are also true for southern declinations and latitudes, which have negative signs.

b. Any question concerning meridian zenith distance of a star on the observer's meridian may be answered easily by drawing a diagram similar to figure 6-2. For observation purposes, any star north of the observer's zenith is considered a north star and any star south of the zenith is considered a south star, regardless of whether it has a positive or negative declination.

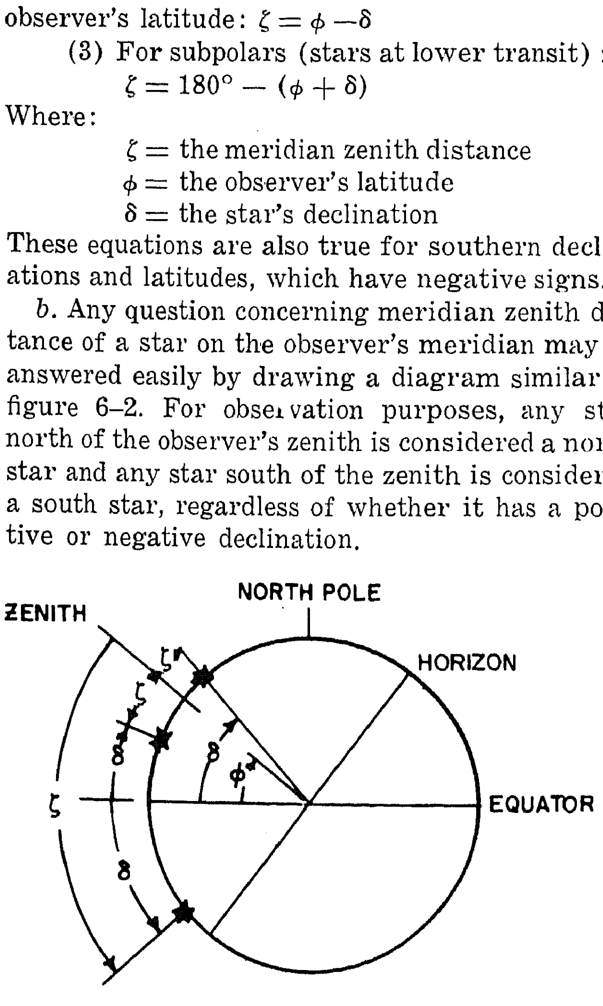


Figure 6-2. Meridian zenith distance.

c. In the ocular east position, the circle setting for a north star (a star north of the zenith) is equal to the zenith distance; for a south star the circle setting is equal to the explement of the zenith distance ($360^\circ - \zeta$). In the ocular west position the opposite is true. See figure 6-3.

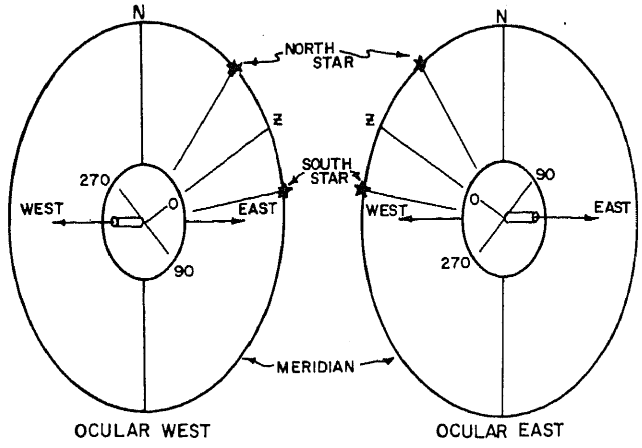


Figure 6-3. Setting circle in relation to celestial sphere.

d. Since a star in longitude observation is observed in both ocular east and ocular west position, the circle is set for both values. In the case of a north star with a zenith distance of 20° and the instrument ocular east, the circle is first set 20° and the telescope moved until the bubble is leveled. The circle is then set to 340° without disturbing the telescope. After the instrument is reversed to ocular west, moving the telescope vertically to level the bubble sets the instrument for the star.

e. By setting both circle readings before the star appears, the observer has only to level the setting circle bubble upon reversal. This makes the observation program much smoother and gives the observer more time to read the hanging level and reverse the instrument. If, after the circle has been set and the bubble leveled, the star does not come near the center wire he should move the telescope by means of the vertical slow motion screw. The telescope should not be clamped in position beyond the point where there is enough friction to prevent the telescope from shifting under its own weight.

6-7. Eyepiece Micrometer

a. The eyepiece micrometer when set properly for longitude work has the shaft of the handwheels perpendicular to the axis of the telescope barrel. The movable wire is then parallel to the meridian.

b. Having the telescope oriented for the star and the setting circle properly set to pick up the star after reversal, the observer must now place the movable wire in the proper position.

c. When the instrument is in the ocular east position, a star enters the scope above the "05" wire, passes over the 05, 10, and 15 wires and on out of the field of view i.e., it comes in at the top of the eyepiece. In the ocular west position a star enters the scope below the "15" wire, passes over the 15, 10 and 05 wires and on out of the field of view i.e., it comes in at the bottom of the eyepiece. For subpolar stars the opposite is true. Because the usable field is considered to be only between the 05 and the 15 wires, the observer should place the movable wire around the 04½/15½ setting depending on the ocular east/west position, before tracking begins. This procedure insures a good bisection of the star when it does pass over the 05/15 wire.

d. The observer must remember to have the movable wire in the proper position before the star appears in the scope. Tracking the star in toward the center of the scope (10 wire) the observer stops tracking around the 7½/12½ wire and does not disturb the movable wire again until the instrument has been reversed and the star is again on the movable wire. After stopping track at the 7½/12½ wire, the observer reads the level, reverses the instrument, and resets the telescope. If this is done rapidly the observer must wait for the star to come back upon the movable wire. The observer, after the instrument has been reversed, must *never* move the movable wire up (or down) to meet the star.

e. The tracking should be done in a very smooth manner, keeping the star carefully bisected at all times. The suggested method is to use both hands and move the wheel through short motions, alternating thumbs pushing and pulling as the case may be. Note that the movable wire appears to move in the opposite direction of the thumbs.

f. Notice that in case of ocular "east/west" the star is tracked from the "05/15" wire to about the "07½/12½" position, the instrument reversed, and the star tracked out past the wire over which it came in. The amount the wire is moved into the field of the telescope is unimportant except that at least 20 corresponding breaks must be obtained. Notice also that stars with high declinations appear to move much more slowly than do equatorial stars, allowing them to be tracked farther toward the center of the optical field without reducing available time for reversal of the instrument.

6–8. Observing List

a. The specifications for the observing list (fig. 6–4) have been stated in paragraph 6–2*a*(2). All that need be known for the preparation of the DA Form 3618-R (Observing List for Longitude) is the local sidereal time at which the observation is to begin and the station latitude. Again, since local sidereal time is equal to the right ascension of a star on the observer's meridian, the list begins at that right ascension for the start of observations and continues for a period of approximately 12 hours. DA Form 3618–R will be reproduced locally on 8 x 10½-inch paper (image size 7 x 10 1/6) (fig. 6–4a).

b. For convenience in forming the list a table of the "A" factors has been provided as table B–1, appendix B. Where the "A" factor is needed to a high accuracy it should be computed with five place trigonometric functions.

6–9. Observation Records

a. DA Form 2844 (fig. 6–5) is used to record all information (except the information recorded on the chronograph) needed to compute the longitude. The following information is included in addition to that required by the form format:

(1) The name of the assistant observer. If an assistant is not used and the bubble is read by the observer it shall be so stated.

(2) The position of the bubble, e.g., whether the low number end is toward or away from the eyepiece.

(3) Ocular position (east or west) at the start of tracking procedure.

(4) Releveling of the bubble. Whether or not leveled between sets.

(5) The serial number of the hanging level vial.

(6) Remarks pertinent to the tracking, e.g., picked up late, dim, through haze, etc.

(7) Identification of radio signal and frequency.

(8) Mean temperature and atmospheric pressure for each set.

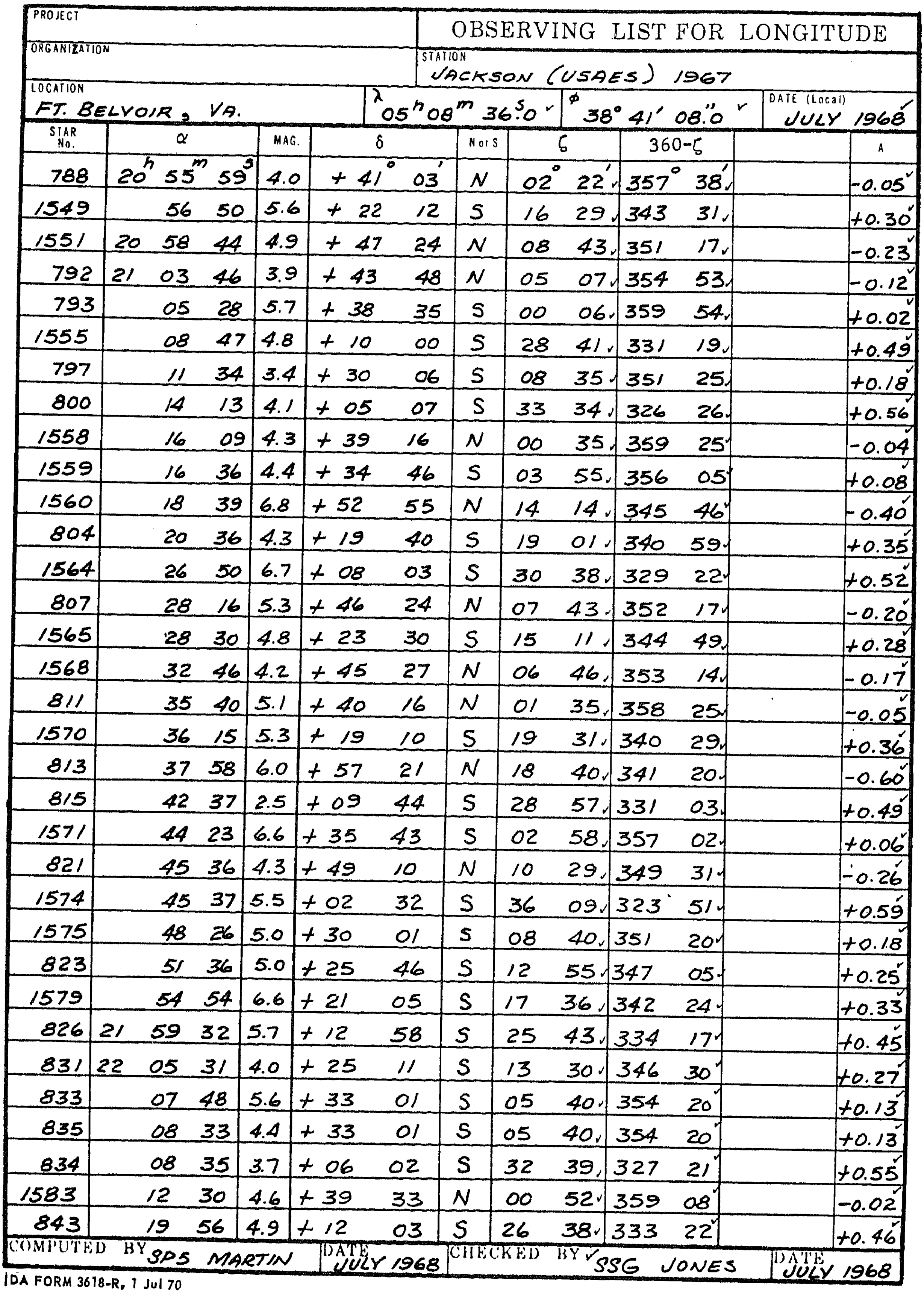
(9) What filter and amplifier settings were used during the radio-chronometer comparisons.

b. When a radio-chronometer comparison is made the recorder should also make an eye-ear comparison and enter this on DA Form 2844, as it is an invaluable aid where the question of the correct minute arises.

c. The recorder should check the level lengths to insure that no errors have been made. If errors have been made, he should see that they are corrected or that additional stars are observed. He should keep a running record of the "A" factors and insure that the "ΣA" for the set never exceeds ± 1.00.

6–10. Checking the Level Record

Subtracting the smaller level reading from the larger reading, with the instrument in one posi-



PROJECT

ORGANIZATION

OBSERVING LIST FOR LONGITUDE

STATION JACKSON (USAES) 1967

LOCATION FT. BELVOIR, VA.

λ 05h 08m 36.s0 ✓

φ 38° 41′ 08.″0 ✓

DATE (Local) JULY 1968 ✓

STAR No.	α			MAG.	δ		N or S	ζ		360-ζ			A
788	20h	55m	59s	4.0	+ 41°	03′	N	02°	22′ ✓	357°	38′ ✓		-0.05 ✓
1549		56	50	5.6	+ 22	12	S	16	29 ✓	343	31 ✓		+0.30 ✓
1551	20	58	44	4.9	+ 47	24	N	08	43 ✓	351	17 ✓		-0.23 ✓
792	21	03	46	3.9	+ 43	48	N	05	07 ✓	354	53 ✓		-0.12 ✓
793		05	28	5.7	+ 38	35	S	00	06 ✓	359	54 ✓		+0.02 ✓
1555		08	47	4.8	+ 10	00	S	28	41 ✓	331	19 ✓		+0.49 ✓
797		11	34	3.4	+ 30	06	S	08	35 ✓	351	25 ✓		+0.18 ✓
800		14	13	4.1	+ 05	07	S	33	34 ✓	326	26 ✓		+0.56 ✓
1558		16	09	4.3	+ 39	16	N	00	35 ✓	359	25 ✓		-0.04 ✓
1559		16	36	4.4	+ 34	46	S	03	55 ✓	356	05 ✓		+0.08 ✓
1560		18	39	6.8	+ 52	55	N	14	14 ✓	345	46 ✓		-0.40 ✓
804		20	36	4.3	+ 19	40	S	19	01 ✓	340	59 ✓		+0.35 ✓
1564		26	50	6.7	+ 08	03	S	30	38 ✓	329	22 ✓		+0.52 ✓
807		28	16	5.3	+ 46	24	N	07	43 ✓	352	17 ✓		-0.20 ✓
1565		28	30	4.8	+ 23	30	S	15	11 ✓	344	49 ✓		+0.28 ✓
1568		32	46	4.2	+ 45	27	N	06	46 ✓	353	14 ✓		-0.17 ✓
811		35	40	5.1	+ 40	16	N	01	35 ✓	358	25 ✓		-0.05 ✓
1570		36	15	5.3	+ 19	10	S	19	31 ✓	340	29 ✓		+0.36 ✓
813		37	58	6.0	+ 57	21	N	18	40 ✓	341	20 ✓		-0.60 ✓
815		42	37	2.5	+ 09	44	S	28	57 ✓	331	03 ✓		+0.49 ✓
1571		44	23	6.6	+ 35	43	S	02	58 ✓	357	02 ✓		+0.06 ✓
821		45	36	4.3	+ 49	10	N	10	29 ✓	349	31 ✓		-0.26 ✓
1574		45	37	5.5	+ 02	32	S	36	09 ✓	323	51 ✓		+0.59 ✓
1575		48	26	5.0	+ 30	01	S	08	40 ✓	351	20 ✓		+0.18 ✓
823		51	36	5.0	+ 25	46	S	12	55 ✓	347	05 ✓		+0.25 ✓
1579		54	54	6.6	+ 21	05	S	17	36 ✓	342	24 ✓		+0.33 ✓
826	21	59	32	5.7	+ 12	58	S	25	43 ✓	334	17 ✓		+0.45 ✓
831	22	05	31	4.0	+ 25	11	S	13	30 ✓	346	30 ✓		+0.27 ✓
833		07	48	5.6	+ 33	01	S	05	40 ✓	354	20 ✓		+0.13 ✓
835		08	33	4.4	+ 33	01	S	05	40 ✓	354	20 ✓		+0.13 ✓
834		08	35	3.7	+ 06	02	S	32	39 ✓	327	21 ✓		+0.55 ✓
1583		12	30	4.6	+ 39	33	N	00	52 ✓	359	08 ✓		-0.02 ✓
843		19	56	4.9	+ 12	03	S	26	38 ✓	333	22 ✓		+0.46 ✓

COMPUTED BY SP5 MARTIN | DATE JULY 1968 | CHECKED BY ✓ SSG JONES | DATE JULY 1968

DA FORM 3618-R, 1 Jul 70

Figure 6-4. Longitude observing list.

PROJECT		**OBSERVING LIST FOR LONGITUDE** TM 5-442	
ORGANIZATION		STATION	
LOCATION	λ	φ	DATE (LOCAL)

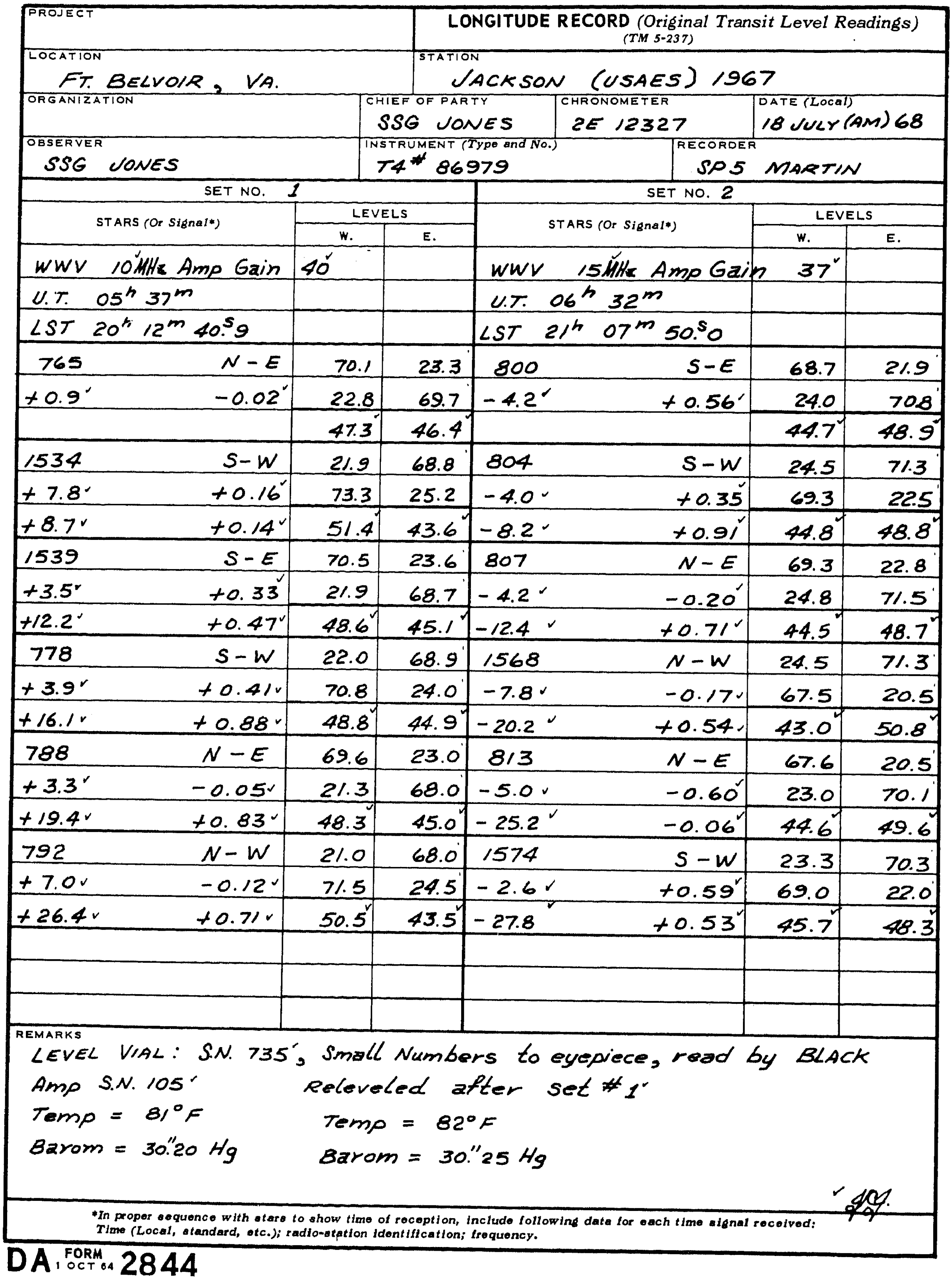
STAR	α	MAG	δ	N or S	ζ	$360 - \zeta$	AZIMUTH	A

COMPUTED BY	DATE	CHECKED BY	DATE

DA FORM 3618-R, 1 Jul 70

(Paper size 8 x 10½", image 7 x 10-1/6")

Figure 6-4a. DA Form 3618-R.



PROJECT	**LONGITUDE RECORD** *(Original Transit Level Readings)* *(TM 5-237)*		
LOCATION FT. BELVOIR, VA.	STATION JACKSON (USAES) 1967		
ORGANIZATION	CHIEF OF PARTY SSG JONES	CHRONOMETER 2E 12327	DATE *(Local)* 18 JULY (AM) 68
OBSERVER SSG JONES	INSTRUMENT *(Type and No.)* T4# 86979	RECORDER SP5 MARTIN	

SET NO. 1				SET NO. 2			
STARS *(Or Signal*)*		LEVELS		STARS *(Or Signal*)*		LEVELS	
		W.	E.			W.	E.
WWV 10MHz Amp Gain		40		WWV 15MHz Amp Gain		37	
U.T. $05^h\ 37^m$				U.T. $06^h\ 32^m$			
LST $20^h\ 12^m\ 40.^s9$				LST $21^h\ 07^m\ 50.^s0$			
765	N - E	70.1	23.3	800	S - E	68.7	21.9
+0.9	-0.02	22.8	69.7	-4.2	+0.56	24.0	70.8
		47.3	46.4			44.7	48.9
1534	S - W	21.9	68.8	804	S - W	24.5	71.3
+7.8	+0.16	73.3	25.2	-4.0	+0.35	69.3	22.5
+8.7	+0.14	51.4	43.6	-8.2	+0.91	44.8	48.8
1539	S - E	70.5	23.6	807	N - E	69.3	22.8
+3.5	+0.33	21.9	68.7	-4.2	-0.20	24.8	71.5
+12.2	+0.47	48.6	45.1	-12.4	+0.71	44.5	48.7
778	S - W	22.0	68.9	1568	N - W	24.5	71.3
+3.9	+0.41	70.8	24.0	-7.8	-0.17	67.5	20.5
+16.1	+0.88	48.8	44.9	-20.2	+0.54	43.0	50.8
788	N - E	69.6	23.0	813	N - E	67.6	20.5
+3.3	-0.05	21.3	68.0	-5.0	-0.60	23.0	70.1
+19.4	+0.83	48.3	45.0	-25.2	-0.06	44.6	49.6
792	N - W	21.0	68.0	1574	S - W	23.3	70.3
+7.0	-0.12	71.5	24.5	-2.6	+0.59	69.0	22.0
+26.4	+0.71	50.5	43.5	-27.8	+0.53	45.7	48.3

REMARKS

LEVEL VIAL: S.N. 735, Small Numbers to eyepiece, read by BLACK

Amp S.N. 105 Releveled after set #1

Temp = 81°F Temp = 82°F

Barom = 30.″20 Hg Barom = 30.″25 Hg

*In proper sequence with stars to show time of reception, include following data for each time signal received: Time (Local, standard, etc.); radio-station identification; frequency.

DA FORM 1 OCT 64 **2844**

Figure 6–5. Longitude record.

tion, gives the length of the bubble in graduations. As the length of the bubble varies only slightly during a night's operation, a difference of more than one graduation upon reversal indicates an error in reading the level and may cause rejection of the observation in which it occurs. The bubble length may gradually increase or decrease as the ambient temperature changes, but the length will not fluctuate. Therefore, if fluctuation does occur, it indicates an inconsistency of interpolation in reading the bubble ends.

6-11. Measuring Scale

Since the time and star observations are transformed into a measure of length on the chronograph, the marks can be measured and read by the use of glass or plastic scales.

a. Since choice of design is a matter of preference, several designs have been used by various units. One such type, found to be quite acceptable (fig. 6-6), is photographed into stable base film. It has the following characteristics: a height of 135 mm, a base 70 mm wide, and a top 15 mm wide. Between the base and the top are parallel lines about 6.75 mm apart. Both the top and base are divided into 20 equal spaces with lines joining the corresponding parts.

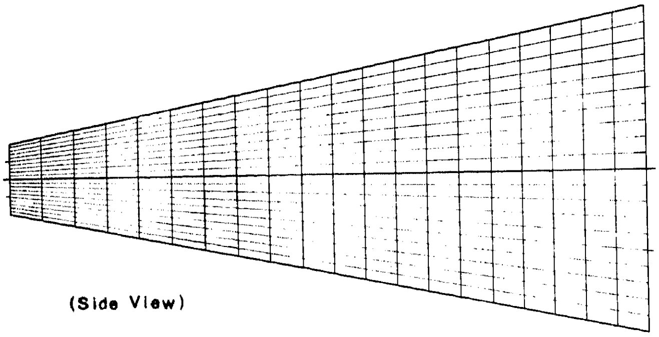


Figure 6-6. Measuring scale.

b. The parallel lines are used to line up the scale on the chronograph record, while the converging lines are used to scale the record. Inconsistent speeds of the chronograph may cause the length of the seconds to vary on the record. The scale may be shifted vertically to get a perfect match between the recorded seconds and the converging lines. With such a scale the time may be easily scaled to 0.1 second.

6-12. Radio-Chronometer Comparison

a. Before scaling the star transits the radio-chronometer comparisons (fig. 6-7) are scaled and computed to find if all are usable; incorrect or insufficient comparisons can cause rejection of one or more sets. DA Form 2845 (Radio Time Signals) is used to record the sending time of signal (radio time), and the local chronometer time of signal (corresponding chronometer time) from the chronograph strip.

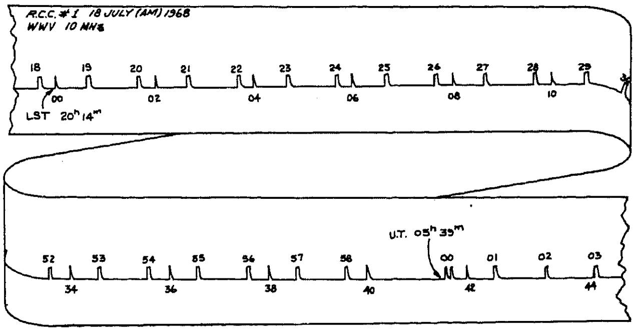


Figure 6-7. Radio-chronometer comparison.

b. With the radio-chronometer comparison tape laid out, the computer identifies the exact minutes and writes, by each chronometer second and each identifiable radio break, its value in seconds. Using a suitable scale, the chronometer time to the nearest $0^{s}.01$ is determined for each radio second (fig. 6-8). At least 20 signals are scaled.

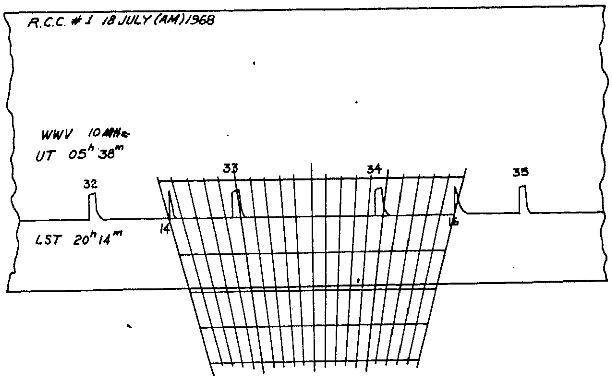


Figure 6-8. Scaling the chronometer time of a radio signal.

c. The mean epoch is the mean of the radio seconds (adding 60^{s} to each radio second after a change of 1 minute if this has occurred) entered to the nearest $0^{s}.0001$. The adopted mean epoch is the time to the full second nearest the mean epoch. The mean scaled reading is the mean of the scaled chronometer times to the nearest $0^{s}.0001$.

d. Each of the radio signals may now be reduced to the adopted mean epoch by addition or subtraction of the difference in time between the signal in question and the adopted mean epoch. Addition or subtraction of this same value to the corresponding chronometer time of the signal in question would not be correct since the chronometer runs on sidereal time and the radio signals are in mean solar time. A correction must be applied to the chronometer time because of sidereal gain, e.g.:

(1) If the adopted mean epoch was $38^m 45^s$ and the corresponding chronometer time $14^m 26^s.48$ and the signal in question was $38^m 33^s$ with a corresponding chronometer time of $14^m 14^s.45$, a value of 12^s must be added to reduce the radio signal to the mean epoch. To reduce the corresponding chronometer time of signal to the mean epoch, 12^s must be added, plus the amount that sidereal time has gained in the 12^s or $0^s.033$ for a total correction of $+12^s.033$.

(2) The correction to reduce sidereal time for a corresponding mean time interval is $0^s.00273791$ per mean solar second. The corrections are tabulated in table B–2, appendix B, with the time in seconds from the mean epoch as the argument. The correction before the mean epoch is added to the chronometer time; after the mean epoch, it is subtracted from the chronometer time. An arithmetic mean to the nearest $0^s.0001$ is the corresponding chronometer time of the mean epoch. Any signal that varies from the mean by more than $\pm\, 0^s.020$ must be rejected and a new mean computed.

e. A correction, mean to sidereal time, is now determined for the time interval between the mean epoch of the radio signals and the adopted mean epoch. This correction is applied to the mean of the scaled readings (positive if the adopted mean epoch time is later than the mean epoch time). The result should agree with the mean of the local chronometer times of the mean epoch within $\pm\, 0^s.0003$; if not, an error has been made. The local chronometer time of the mean epoch correct to $0^s.001$ is entered as the corresponding chronometer time (fig. 6–9).

6–13. Radio Time Signals

The time signals used must be of scientific quality, must be broadcast from a station of known position, and must be monitored by an authoritative observatory that publishes a periodic list of corrections to signals.

a. The desirable time signal to use in the western hemisphere is broadcast by the National Bureau of Standards over radio station WWV at Fort Collins, Colo. These signals are broadcast 24 hours a day at frequencies of 2.5, 5, 10, 15, 20, and 25 megahertz, starting at 11 minutes before each hour and continuing until 45 minutes after each hour. The signal is a 1000 h_z pulse of 0.005-second duration broadcast at each second, omitting the 59th second, and with a double signal 0.1 sec apart on the full minute. The exact second is referenced to the beginning of the 1000 h_z pulse. The Greenwich Mean Time is broadcast by voice prior to each 5-minute interval.

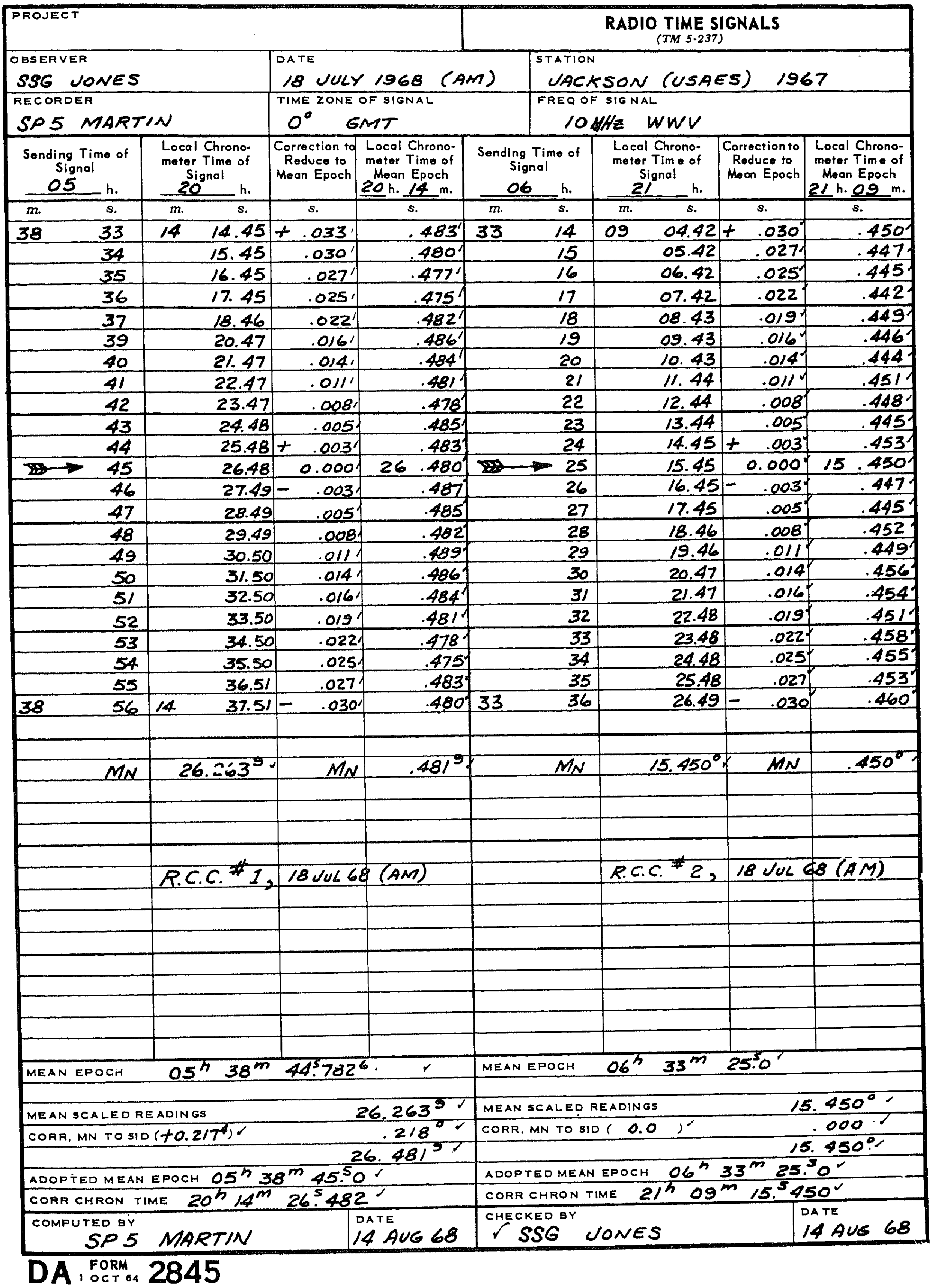
b. Suitable signals to use in the eastern hemisphere are those broadcast by radio station JJY at Koganei, Tokyo, Japan. These signals are broadcast 24 hours a day on frequencies of 2.5, 5, 10, and 15 megahertz, starting at 21 minutes before each hour and continuing until 25 minutes after the hour. The signal is a 1600 h_z pulse of 0.005-second duration broadcast at each second. The full minute is marked as the 1600 h_z pulse *following* a 600 h_z marker pulse of 0.655-second duration. The Japanese Standard Time (135°E) is broadcast by voice in Japanese during the intervals 34 to 35 minutes and 59 to 60 minutes of each hour. The carrier wave is modulated at 1000 hertz during the intervals 0 to 10 minutes, 20 to 25 minutes, and 40 to 50 minutes of each hour. The exact second is referred to the beginning of the 1600 h_z pulse. The 1000 hertz band-pass filter should not be used to record JJY. Its presence would result in the second pulse being filtered out, but the beginning of the modulation tone (1000 hertz) would be recorded $0^s.045$. later and mistaken for the beginning of the second pulse.

c. Several other transmitting stations broadcast time signals of scientific quality that may be used during longitude observations. Appendix D gives call signs, frequencies, and locations of the most frequently used transmitters. Positions of monitoring observatories are also listed. The monthly bulletin (Circular D) and Annual Reports of the Bureau International de l'Heure (BIH), Paris, should be consulted for the most comprehensive and current information relative to transmitter locations and emission time corrections for the various worldwide radio time signals broadcast by coordinated observatories and time services. The Circular D bulletins are distributed through the US Naval Observatory.

6–14. Chronometer Corrections and Rates

After all mean radio signal epochs and their corresponding chronometer times have been computed they are entered on DA Form 2847 (Comparison of Chronometer and Radio Signals) in chronological order. The form is self-explanatory and requires only the following comments:

a. Change in Nutation. The values of apparent sidereal time at 0^h UT include the values of long and short period terms of nutation (equation of



PROJECT

RADIO TIME SIGNALS

(TM 5-237)

OBSERVER SSG JONES
DATE 18 JULY 1968 (AM)
STATION JACKSON (USAES) 1967
RECORDER SP5 MARTIN
TIME ZONE OF SIGNAL 0° GMT
FREQ OF SIGNAL 10 MHz WWV

Sending Time of Signal 05 h.		Local Chronometer Time of Signal 20 h.		Correction to Reduce to Mean Epoch	Local Chronometer Time of Mean Epoch 20 h. 14 m.	Sending Time of Signal 06 h.		Local Chronometer Time of Signal 21 h.		Correction to Reduce to Mean Epoch	Local Chronometer Time of Mean Epoch 21 h. 09 m.
m.	s.	m.	s.	s.	s.	m.	s.	m.	s.	s.	s.
38	33	14	14.45	+ .033	.483	33	14	09	04.42	+ .030	.450
	34		15.45	.030	.480		15		05.42	.027	.447
	35		16.45	.027	.477		16		06.42	.025	.445
	36		17.45	.025	.475		17		07.42	.022	.442
	37		18.46	.022	.482		18		08.43	.019	.449
	39		20.47	.016	.486		19		09.43	.016	.446
	40		21.47	.014	.484		20		10.43	.014	.444
	41		22.47	.011	.481		21		11.44	.011	.451
	42		23.47	.008	.478		22		12.44	.008	.448
	43		24.48	.005	.485		23		13.44	.005	.445
	44		25.48	+ .003	.483		24		14.45	+ .003	.453
→	45		26.48	0.000	26 .480	→	25		15.45	0.000	15 .450
	46		27.49	− .003	.487		26		16.45	− .003	.447
	47		28.49	.005	.485		27		17.45	.005	.445
	48		29.49	.008	.482		28		18.46	.008	.452
	49		30.50	.011	.489		29		19.46	.011	.449
	50		31.50	.014	.486		30		20.47	.014	.456
	51		32.50	.016	.484		31		21.47	.016	.454
	52		33.50	.019	.481		32		22.48	.019	.451
	53		34.50	.022	.478		33		23.48	.022	.458
	54		35.50	.025	.475		34		24.48	.025	.455
	55		36.51	.027	.483		35		25.48	.027	.453
38	56	14	37.51	− .030	.480	33	36		26.49	− .030	.460
	MN		26.263^{9} ✓	MN	$.481^{9}$ ✓		MN		15.450^{0} ✓	MN	$.450^{0}$ ✓
		R.C.C. #1,		18 JUL 68 (AM)				R.C.C. #2,		18 JUL 68 (AM)	

MEAN EPOCH $05^{h}\ 38^{m}\ 44^{s}.782^{6}$ ✓	MEAN EPOCH $06^{h}\ 33^{m}\ 25^{s}.0$ ✓
MEAN SCALED READINGS 26.263^{9} ✓	MEAN SCALED READINGS 15.450^{0} ✓
CORR, MN TO SID ($+0.217^{4}$) ✓ $.218^{0}$ ✓	CORR, MN TO SID (0.0) ✓ .000 ✓
26.481^{9} ✓	15.450^{0} ✓
ADOPTED MEAN EPOCH $05^{h}\ 38^{m}\ 45^{s}.0$ ✓	ADOPTED MEAN EPOCH $06^{h}\ 33^{m}\ 25^{s}.0$ ✓
CORR CHRON TIME $20^{h}\ 14^{m}\ 26^{s}.482$ ✓	CORR CHRON TIME $21^{h}\ 09^{m}\ 15^{s}.450$ ✓
COMPUTED BY SP5 MARTIN DATE 14 AUG 68	CHECKED BY ✓ SSG JONES DATE 14 AUG 68

DA FORM 1 OCT 64 2845

Figure 6—9. Radio time signals.

the equinoxes). As the radio-chronometer comparisons are seldom computed for 0^h UT, a correction for the change in nutation that has occurred between 0^h UT and the UT of the radio-chronometer comparison is required. The correction is determined by using the UT of the signal converted to decimal parts of a day as the interpolating argument. Tabular values of nutation are found in the APFS, table II, under "Equation of the Equinoxes"; "Long Period" and "Short Period".

	Long period	*Short period*
Tabular value at 0^h UT 14 Dec 68	$-0^{s}.124$	$-0^{s}.008$
Tabular value at 0^h UT 15 Dec 68	-0.120	-0.014
Change	$+0.004$	-0.006
Total change	$-0^{s}.002$	
UT of signal $05^h\ 38^m\ 45^s$ 14 Dec 68		
As decimal part of a day	$0^{d}.235$	
Corr for change in nutation = (0.235) (−0.002) =		$-0^{s}.000$

Since the values of long and short period terms of nutation are included in the listed apparent sidereal time, only the change and not the total values are required.

NOTE

The example for 14 December 1968 was used, as the total change for 18–19 July 1968 was $0^{s}.000$

b. Transmission Time. The time required for a radio signal to travel from the transmitting station to the field station is not instantaneous but varies with the distance between the stations. Where only one signal source is used, the usual practice, the correction is a constant at any one field station and is applied to the observed longitude. When more than one transmitting station has been used it becomes an individual correction for the appropriate comparison (para. 6–25).

c. Correction to Signal. Small corrections must be applied to the emitted time signals of coordinated radio time service stations. For explanation of the source and application of these corrections see the appropriate bulletins of the BIH. In addition, correction bulletins are published by certain worldwide observatories in cooperation with BIH.

(1) The most easily obtained correction bulletins are those published by the US Naval Observatory. Preliminary corrections are published weekly. These time signal correction bulletins and the BIH Circular D may be obtained regularly by writing to Times Service Division, US Naval Observatory, Washington, D. C., 20390. A Preliminary Time Signal Correction Bulletin is shown in figure 6–10. When the correction is entered on the radio-chronometer comparison, it should be noted whether the preliminary or final correction is used. A BIH Circular D is shown in figure 6–11.

(2) All longitude observations are referred to UT1. Therefore the quantity to be used is for UT1–UTC. Unless otherwise stated it is understood that the correction is in terms of hundredths or thousandths of a second. For example, if the correction is "0040" the time of the signal was $0^{s}.0040$ late, or if the correction is "9970" the signal was $0^{s}.0030$ early. The corrections are applied algebraically, as below, remembering that eastern longitudes are considered negative and western longitudes positive.

Signal	Sign of the correction
Early	Negative
Late	Positive

Often when the correction is constant during an entire observation it is applied as a correction to the observed longitude.

d. Rate. The chronometer correction assumes the sign obtained by subtracting "Local Sidereal Times" minus "Chronometer Time of Signal". The rate in seconds per minute for any two radio-chronometer comparisons is computed from the expression:

$$\text{Rate} = \frac{(\text{2d chrono corr in seconds}) - (\text{1st chrono corr in seconds})}{(\text{2d chrono time in minutes}) - (\text{1st chrono time in minutes})}$$

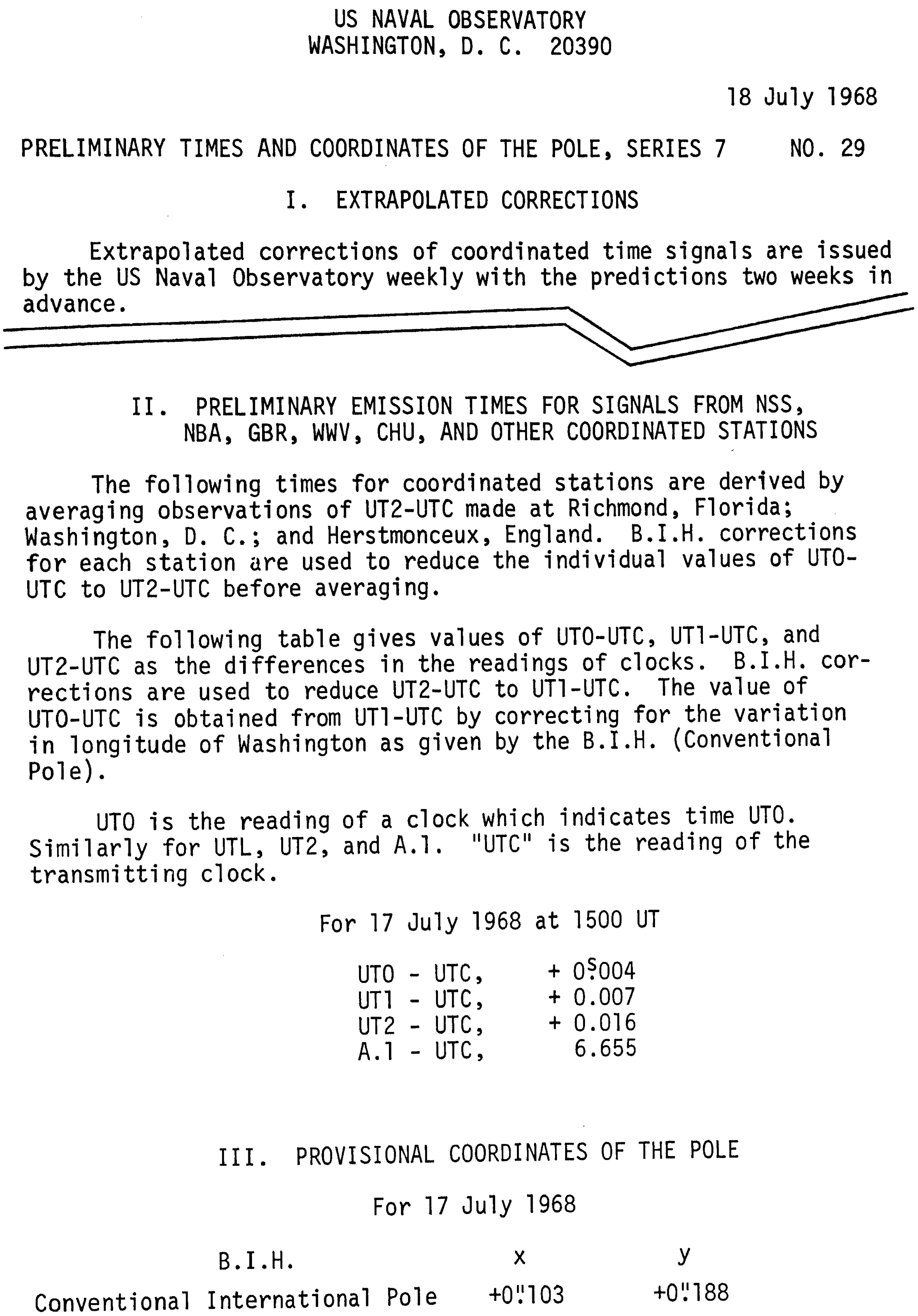
An inspection of the rates is very important. If the rates are erratic or change in sign, a mistake in the computation should be suspected, although an error by the recorder may have caused the deviation. Movement of the chronometer also causes a rate change. If the change in the rate is large or the signs fluctuate, rejection of the comparison should be considered if no error can be found. The chronometer rate is "negative/positive" if the chronometer is "gaining/losing" on sidereal time (fig. 6–12).

6–15. Scaling the Transit Time

a. Considering only the "0" contact of the eyepiece micrometer, the relative positions of the movable wire and the corresponding time on the chronograph strip of a star transit may be shown as in figure 6–13.

If 1, 2, and 3 are the positions of the movable wire in the field before reversal and 3′, 2′, and 1′ are the corresponding positions after reversal, the following relationship exists:

$$\text{M (mean point of transit)} = \frac{1+1'}{2} = \frac{2+2'}{2} = \frac{3+3'}{2}$$



US NAVAL OBSERVATORY
WASHINGTON, D. C. 20390

18 July 1968

PRELIMINARY TIMES AND COORDINATES OF THE POLE, SERIES 7 NO. 29

I. EXTRAPOLATED CORRECTIONS

Extrapolated corrections of coordinated time signals are issued by the US Naval Observatory weekly with the predictions two weeks in advance.

II. PRELIMINARY EMISSION TIMES FOR SIGNALS FROM NSS, NBA, GBR, WWV, CHU, AND OTHER COORDINATED STATIONS

The following times for coordinated stations are derived by averaging observations of UT2-UTC made at Richmond, Florida; Washington, D. C.; and Herstmonceux, England. B.I.H. corrections for each station are used to reduce the individual values of UTO-UTC to UT2-UTC before averaging.

The following table gives values of UTO-UTC, UT1-UTC, and UT2-UTC as the differences in the readings of clocks. B.I.H. corrections are used to reduce UT2-UTC to UT1-UTC. The value of UTO-UTC is obtained from UT1-UTC by correcting for the variation in longitude of Washington as given by the B.I.H. (Conventional Pole).

UTO is the reading of a clock which indicates time UTO. Similarly for UTL, UT2, and A.1. "UTC" is the reading of the transmitting clock.

For 17 July 1968 at 1500 UT

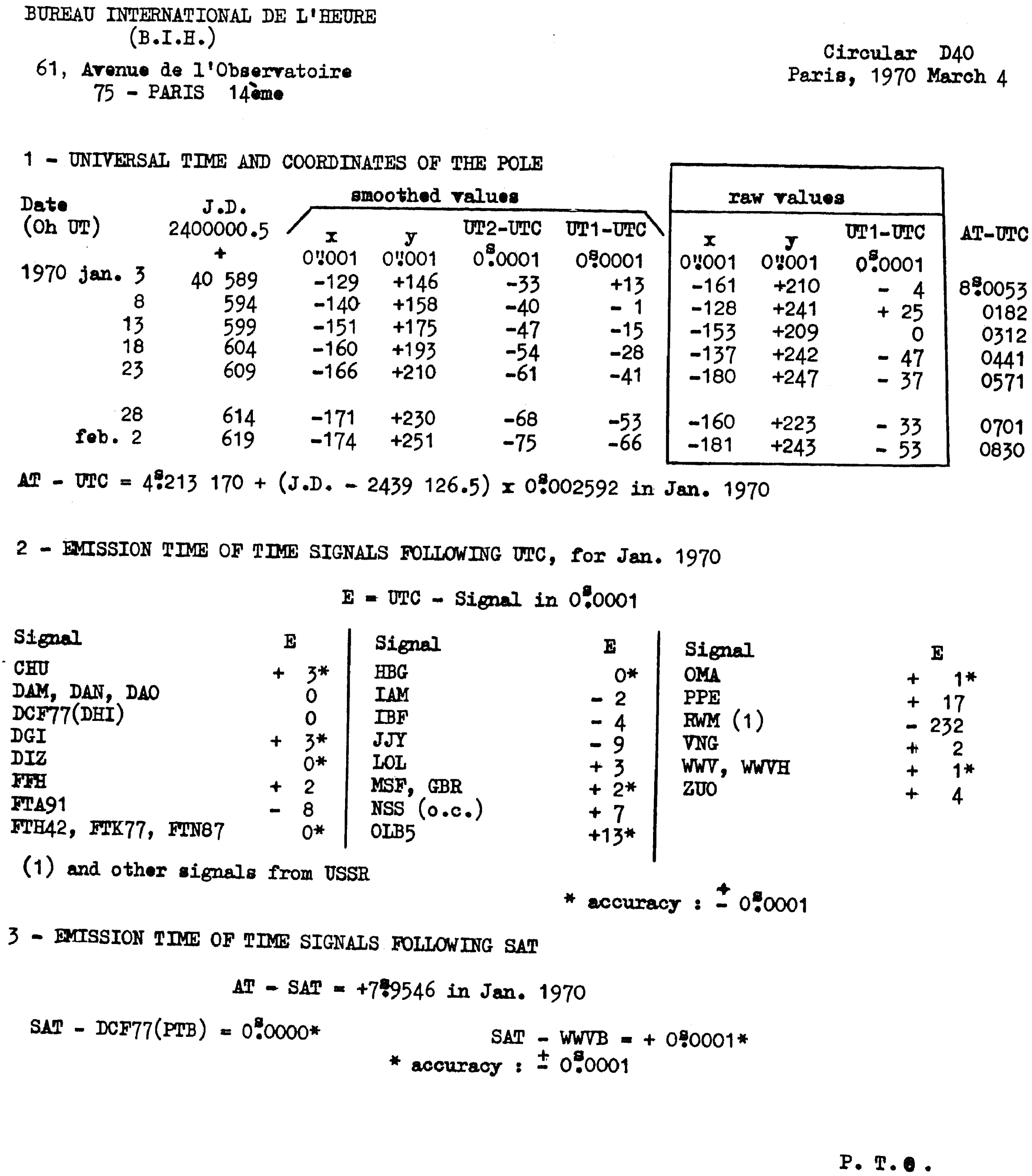
UTO - UTC,	+ 0$^{\mathrm{s}}$.004
UT1 - UTC,	+ 0.007
UT2 - UTC,	+ 0.016
A.1 - UTC,	6.655

III. PROVISIONAL COORDINATES OF THE POLE

For 17 July 1968

B.I.H.	x	y
Conventional International Pole	+0$''$.103	+0$''$.188

Figure 6-10. Preliminary Time Signal Bulletin.



BUREAU INTERNATIONAL DE L'HEURE
(B.I.H.)
61, Avenue de l'Observatoire
75 - PARIS 14ème

Circular D40
Paris, 1970 March 4

1 - UNIVERSAL TIME AND COORDINATES OF THE POLE

Date (0h UT)	J.D. 2400000.5 +	smoothed values				raw values			AT-UTC
		x	y	UT2-UTC	UT1-UTC	x	y	UT1-UTC	
		0".001	0".001	$0^{s}.0001$	$0^{s}.0001$	0".001	0".001	$0^{s}.0001$	
1970 jan. 3	40 589	-129	+146	-33	+13	-161	+210	- 4	$8^{s}.0053$
8	594	-140	+158	-40	- 1	-128	+241	+ 25	0182
13	599	-151	+175	-47	-15	-153	+209	0	0312
18	604	-160	+193	-54	-28	-137	+242	- 47	0441
23	609	-166	+210	-61	-41	-180	+247	- 37	0571
28	614	-171	+230	-68	-53	-160	+223	- 33	0701
feb. 2	619	-174	+251	-75	-66	-181	+243	- 53	0830

AT - UTC = $4^{s}.213\ 170$ + (J.D. - 2439 126.5) x $0^{s}.002592$ in Jan. 1970

2 - EMISSION TIME OF TIME SIGNALS FOLLOWING UTC, for Jan. 1970

E = UTC - Signal in $0^{s}.0001$

Signal	E	Signal	E	Signal	E
CHU	+ 3*	HBG	0*	OMA	+ 1*
DAM, DAN, DAO	0	IAM	- 2	PPE	+ 17
DCF77(DHI)	0	IBF	- 4	RWM (1)	- 232
DGI	+ 3*	JJY	- 9	VNG	+ 2
DIZ	0*	LOL	+ 3	WWV, WWVH	+ 1*
FFH	+ 2	MSF, GBR	+ 2*	ZUO	+ 4
FTA91	- 8	NSS (o.c.)	+ 7		
FTH42, FTK77, FTN87	0*	OLB5	+13*		

(1) and other signals from USSR

* accuracy : ± $0^{s}.0001$

3 - EMISSION TIME OF TIME SIGNALS FOLLOWING SAT

AT - SAT = $+7^{s}.9546$ in Jan. 1970

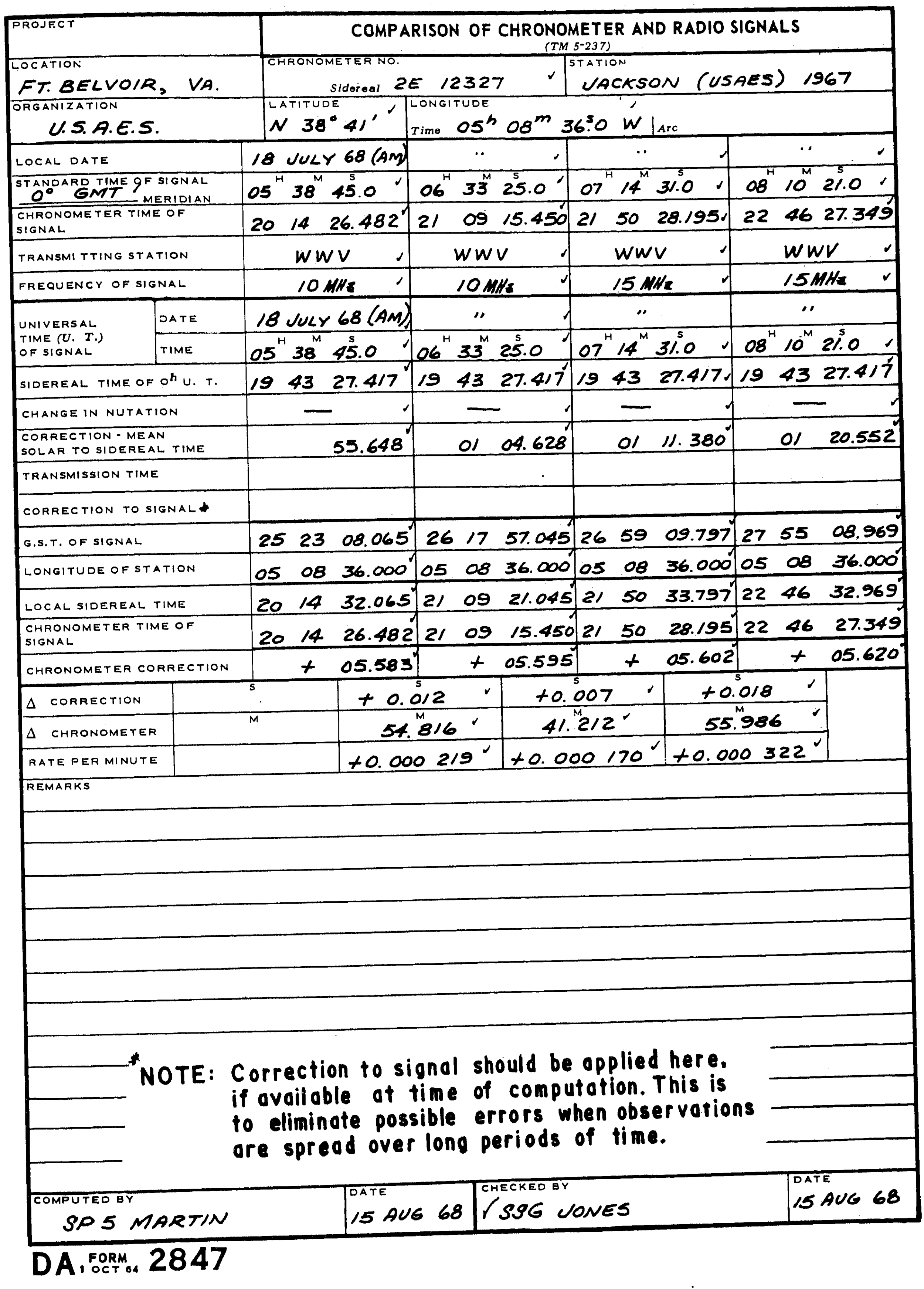
SAT - DCF77(PTB) = $0^{s}.0000$*

SAT - WWVB = + $0^{s}.0001$*

* accuracy : ± $0^{s}.0001$

P. T. O.

Figure 6-11. BIH Circular D.



PROJECT

COMPARISON OF CHRONOMETER AND RADIO SIGNALS
(TM 5-237)

LOCATION: FT. BELVOIR, VA.
CHRONOMETER NO.: Sidereal 2E 12327 ✓
STATION: JACKSON (USAES) 1967
ORGANIZATION: U.S.A.E.S.
LATITUDE: N 38° 41' ✓
LONGITUDE: ✓ Time 05ʰ 08ᵐ 36ˢ.0 W | Arc

LOCAL DATE	18 JULY 68 (AM)	" ✓	" ✓	" ✓
STANDARD TIME OF SIGNAL 0° GMT ? MERIDIAN	H M S 05 38 45.0 ✓	H M S 06 33 25.0 ✓	H M S 07 14 31.0 ✓	H M S 08 10 21.0 ✓
CHRONOMETER TIME OF SIGNAL	20 14 26.482 ✓	21 09 15.450 ✓	21 50 28.195 ✓	22 46 27.349 ✓
TRANSMITTING STATION	WWV ✓	WWV ✓	WWV ✓	WWV ✓
FREQUENCY OF SIGNAL	10 MHz ✓	10 MHz ✓	15 MHz ✓	15 MHz ✓
UNIVERSAL TIME (U. T.) OF SIGNAL — DATE	18 JULY 68 (AM)	" ✓	"	"
UNIVERSAL TIME (U. T.) OF SIGNAL — TIME	H M S 05 38 45.0 ✓	H M S 06 33 25.0 ✓	H M S 07 14 31.0 ✓	H M S 08 10 21.0 ✓
SIDEREAL TIME OF 0ʰ U. T.	19 43 27.417 ✓	19 43 27.417 ✓	19 43 27.417 ✓	19 43 27.417 ✓
CHANGE IN NUTATION	— ✓	— ✓	— ✓	— ✓
CORRECTION - MEAN SOLAR TO SIDEREAL TIME	55.648 ✓	01 04.628 ✓	01 11.380 ✓	01 20.552 ✓
TRANSMISSION TIME				
CORRECTION TO SIGNAL*				
G.S.T. OF SIGNAL	25 23 08.065 ✓	26 17 57.045 ✓	26 59 09.797 ✓	27 55 08.969 ✓
LONGITUDE OF STATION	05 08 36.000 ✓	05 08 36.000	05 08 36.000	05 08 36.000 ✓
LOCAL SIDEREAL TIME	20 14 32.065 ✓	21 09 21.045	21 50 33.797	22 46 32.969 ✓
CHRONOMETER TIME OF SIGNAL	20 14 26.482	21 09 15.450 ✓	21 50 28.195 ✓	22 46 27.349 ✓
CHRONOMETER CORRECTION	+ 05.583 ✓	+ 05.595 ✓	+ 05.602 ✓	+ 05.620 ✓

Δ CORRECTION	S	S + 0.012 ✓	S +0.007 ✓	S +0.018 ✓
Δ CHRONOMETER	M	M 54.816 ✓	M 41.212 ✓	M 55.986 ✓
RATE PER MINUTE		+0.000 219 ✓	+0.000 170 ✓	+0.000 322 ✓

REMARKS

*NOTE: **Correction to signal should be applied here, if available at time of computation. This is to eliminate possible errors when observations are spread over long periods of time.**

COMPUTED BY SP 5 MARTIN	DATE 15 AUG 68	CHECKED BY ✓ SSG JONES	DATE 15 AUG 68

DA FORM 1 OCT 64 2847

Figure 6-12. Computation of radio-chronometer comparison.

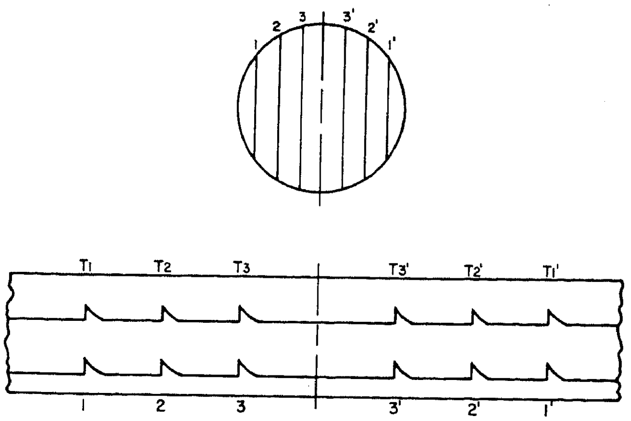


Figure 6-13. Eyepiece micrometer and chronograph record.

However, this relationship is not exact due to inconsistent tracking, therefore a mean is taken:

$$m = \frac{\frac{1+1'}{2} + \frac{2+2'}{2} + \frac{3+3'}{2}}{n}$$

Where "n" is the number of reduced wire positions. The same is true if T_1, T_2, T_3, T_3', T_2', T_1', are the times that the movable wire is in the positions 1, 2, 3, 3′, 2′, 1′, respectively. In practice a total of 20 such determinations is made for each star. In order to avoid dividing each sum by 2 and then by the number of corresponding times, the sums are first divided by "n" and then after rejection divided by 2.

b. DA Form 2846 (Star Transit Scaling) is used for the recording of the transit time. The "0" strip is identified by an extra strip on both sides; these extra strips are not scaled. The computer lays the record for the transit of a star (fig. 6-14) out on a table and letters the corresponding marks, from the time of transit outward, after identification of the "0" strips. (These are usually marked C, B, A, prior to transit and A, B, C, after transit.) After scaling the chronometer times to $0\overset{s}{.}1$ the sums are computed, the mean of the sums determined, and the rejection limit of $\pm\, 0\overset{s}{.}25 \sec \delta$ applied. Where rejections are made a new mean is determined and the rejection limit again applied (fig. 6-15).

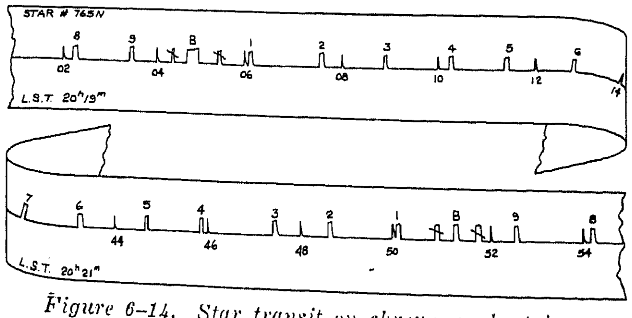


Figure 6-14. Star transit on chronograph strip.

c. A quick check against gross errors may be made by facing any two corresponding marks on the tape record together and folding the tape between the marks. The position of the crease should be quite close to the time of transit, if the chronograph has remained running throughout.

6-16. Observation Corrections Factors

The star numbers and scaled transit times are entered, by set, on DA Form 2848 (Astronomic Longitude Data) in order of observation. The mean declination, tangent, and secant of the mean declination for each star are extracted from the APFS and entered on the form. The sine and cosine of the latitude, to five decimal places, are determined using the most accurately known latitude of the station. The values of B, b, Bb, ʃ, k, and A are then computed to three decimal places.

a. Correction for Inclination. If the instrument were perfectly level, all instrument adjustments perfect, and the instrument in the meridian, vertical motion of the telescope would cause the collimation axis to follow the meridian (fig. 6-16). However, if the horizontal axis is slightly tilted in the plane of the horizon the collimation axis then traces a great circle resulting in an angle being formed at the intersection of the meridian and the horizon (fig. 6-17). If the great circle is to the east of the meridian all stars transit early, and the longitude should be corrected toward the west; if the great circle is to the west all stars transit late and the opposite correction would apply. The reverse is true for subpolar stars.

(1) To correct transit time for the effects of inclination of the horizontal axis, two readings of the hanging level are made. Since the divisions of the hanging level are numbered consecutively from one end to the other, the apparent inclination of the telescope, i, will be—

$$i = (\Delta W - \Delta E)$$

Where:

ΔW = the arithmetic difference of the west end readings of the hanging level, ocular east and ocular west

ΔE = the arithmetic difference of the east end readings of the hanging level, ocular east and ocular west

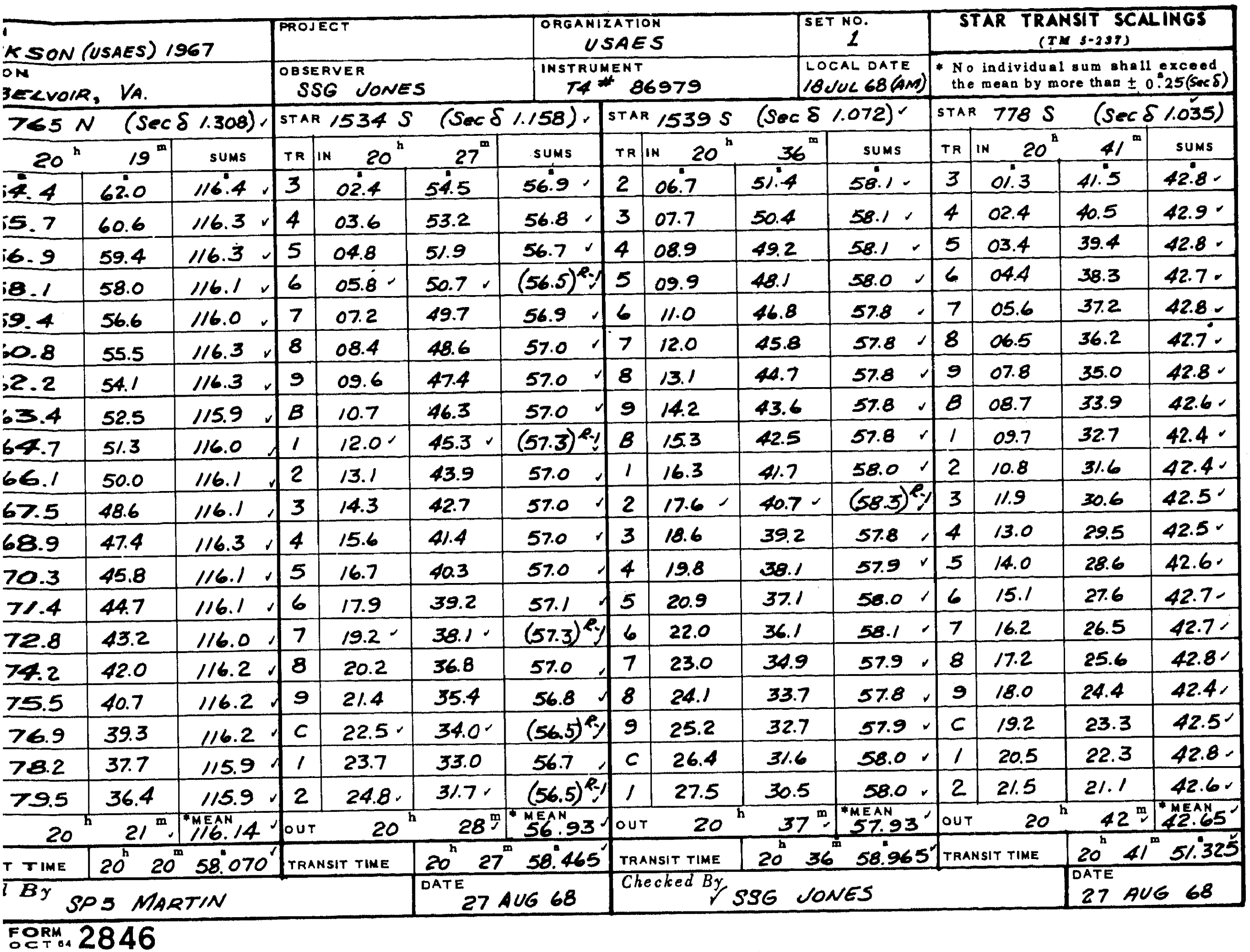
Then the inclination, in the plane of the horizon and in seconds of time "b", will be:

$$b = i\frac{d}{60}$$

Where:

i = inclination in level vial divisions

d = value of one graduation of the hanging level in seconds of arc



KSON (USAES) 1967

ON
BELVOIR, VA.

PROJECT

OBSERVER SSG JONES

ORGANIZATION USAES

INSTRUMENT T4 # 86979

SET NO. 1

LOCAL DATE 18 JUL 68 (AM)

STAR TRANSIT SCALINGS
(TM 5-237)

* No individual sum shall exceed the mean by more than ± $0\overset{s}{.}25$ (Sec δ) ✓

765 N (Sec δ 1.308) ✓

20^{h}	19^{m}	SUMS
4.4	62.0	116.4 ✓
5.7	60.6	116.3 ✓
6.9	59.4	116.3 ✓
8.1	58.0	116.1 ✓
9.4	56.6	116.0 ✓
0.8	55.5	116.3 ✓
2.2	54.1	116.3 ✓
3.4	52.5	115.9 ✓
64.7	51.3	116.0 ✓
66.1	50.0	116.1 ✓
67.5	48.6	116.1 ✓
68.9	47.4	116.3 ✓
70.3	45.8	116.1 ✓
71.4	44.7	116.1 ✓
72.8	43.2	116.0 ✓
74.2	42.0	116.2 ✓
75.5	40.7	116.2 ✓
76.9	39.3	116.2 ✓
78.2	37.7	115.9 ✓
79.5	36.4	115.9 ✓
20^{h}	21^{m} ✓	*MEAN 116.14 ✓

T TIME $20^{h}\ 20^{m}\ 58\overset{s}{.}070$ ✓

STAR 1534 S (Sec δ 1.158) ✓

TR	IN 20^{h}	27^{m}	SUMS
3	02.4	54.5	56.9 ✓
4	03.6	53.2	56.8 ✓
5	04.8	51.9	56.7 ✓
6	05.8 ✓	50.7 ✓	(56.5)$^{R-1}$ ✓
7	07.2	49.7	56.9 ✓
8	08.4	48.6	57.0 ✓
9	09.6	47.4	57.0 ✓
B	10.7	46.3	57.0 ✓
1	12.0 ✓	45.3 ✓	(57.3)$^{R-1}$ ✓
2	13.1	43.9	57.0 ✓
3	14.3	42.7	57.0 ✓
4	15.6	41.4	57.0 ✓
5	16.7	40.3	57.0 ✓
6	17.9	39.2	57.1 ✓
7	19.2 ✓	38.1 ✓	(57.3)$^{R-1}$ ✓
8	20.2	36.8	57.0 ✓
9	21.4	35.4	56.8 ✓
C	22.5 ✓	34.0 ✓	(56.5)$^{R-1}$ ✓
1	23.7	33.0	56.7 ✓
2	24.8 ✓	31.7 ✓	(56.5)$^{R-1}$ ✓
OUT	20^{h}	28^{m} ✓	*MEAN 56.93 ✓

TRANSIT TIME $20^{h}\ 27^{m}\ 58\overset{s}{.}465$ ✓

STAR 1539 S (Sec δ 1.072) ✓

TR	IN 20^{h}	36^{m}	SUMS
2	06.7	51.4	58.1 ✓
3	07.7	50.4	58.1 ✓
4	08.9	49.2	58.1 ✓
5	09.9	48.1	58.0 ✓
6	11.0	46.8	57.8 ✓
7	12.0	45.8	57.8 ✓
8	13.1	44.7	57.8 ✓
9	14.2	43.6	57.8 ✓
B	15.3	42.5	57.8 ✓
1	16.3	41.7	58.0 ✓
2	17.6 ✓	40.7 ✓	(58.3)$^{R-1}$ ✓
3	18.6	39.2	57.8 ✓
4	19.8	38.1	57.9 ✓
5	20.9	37.1	58.0 ✓
6	22.0	36.1	58.1 ✓
7	23.0	34.9	57.9 ✓
8	24.1	33.7	57.8 ✓
9	25.2	32.7	57.9 ✓
C	26.4	31.6	58.0 ✓
1	27.5	30.5	58.0 ✓
OUT	20^{h}	37^{m} ✓	*MEAN 57.93 ✓

TRANSIT TIME $20^{h}\ 36^{m}\ 58\overset{s}{.}965$ ✓

STAR 778 S (Sec δ 1.035) ✓

TR	IN 20^{h}	41^{m}	SUMS
3	01.3	41.5	42.8 ✓
4	02.4	40.5	42.9 ✓
5	03.4	39.4	42.8 ✓
6	04.4	38.3	42.7 ✓
7	05.6	37.2	42.8 ✓
8	06.5	36.2	42.7 ✓
9	07.8	35.0	42.8 ✓
B	08.7	33.9	42.6 ✓
1	09.7	32.7	42.4 ✓
2	10.8	31.6	42.4 ✓
3	11.9	30.6	42.5 ✓
4	13.0	29.5	42.5 ✓
5	14.0	28.6	42.6 ✓
6	15.1	27.6	42.7 ✓
7	16.2	26.5	42.7 ✓
8	17.2	25.6	42.8 ✓
9	18.0	24.4	42.4 ✓
C	19.2	23.3	42.5 ✓
1	20.5	22.3	42.8 ✓
2	21.5	21.1	42.6 ✓
OUT	20^{h}	42^{m} ✓	*MEAN 42.65 ✓

TRANSIT TIME $20^{h}\ 41^{m}\ 51\overset{s}{.}325$ ✓

l By SP5 MARTIN

DATE 27 AUG 68

Checked By ✓ SSG JONES

DATE 27 AUG 68

FORM OCT 64 2846

Figure 6–15. Star transit scaling.

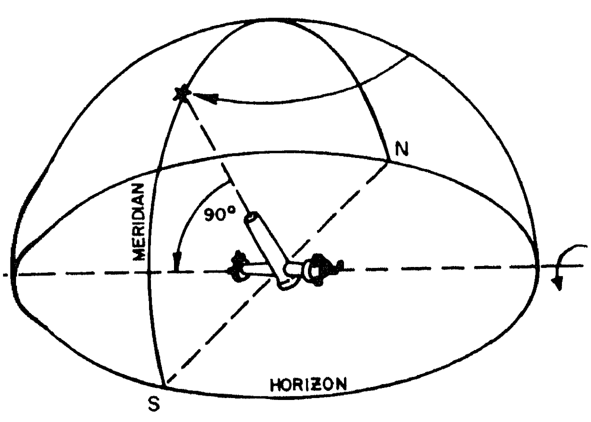
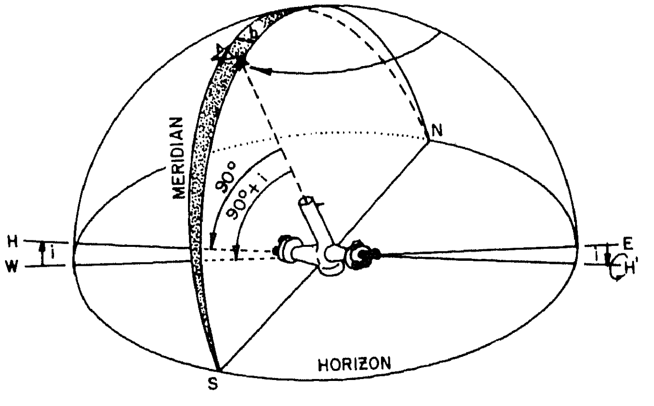


Figure 6–16. Level instrument.



H TO H' IS HORIZONTAL AXIS
i IS INCLINATION OF AXIS
b IS INCLINATION CORRECTION

Figure 6–17. Inclined instrument.

(2) The above formulas give the inclination he plane of the horizon. Since longitude is sured in the plane of the equator, a factor is oduced to effect a transformation. The effect he inclination factor is shown in figure 6–18. inclination factor is given by:

$$B = \cos\phi + \tan\delta\sin\phi$$

here:

ζ = zenith distance of the star

δ = declination of the star

ϕ = latitude of the observer

(3) The values of ΔW and ΔE are recorded on DA Form 2844. A subtraction in the sense (ΔW − ΔE) gives the inclination with the proper algebraic sign. This is entered on DA Form 2848,

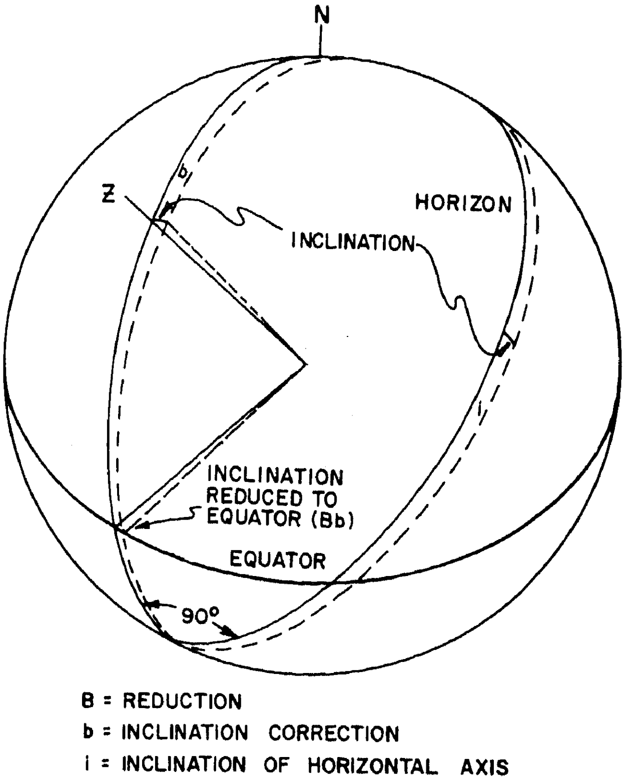

N
Z
b
HORIZON
INCLINATION
INCLINATION REDUCED TO EQUATOR (Bb)
EQUATOR
90°
B = REDUCTION
b = INCLINATION CORRECTION
i = INCLINATION OF HORIZONTAL AXIS

Figure 6-18. Inclination factor.

multiplied by d/60 to give "b", and then by "B" to give the correction "Bb".

b. Correction for Collimation.

(1) If the wire indicating the optical axis of the telescope is actually alined with the optical axis, the line of sight of a perfectly adjusted instrument traces the meridian. If there is some error in the collimation adjustment (fig. 6-19) the wire actually traces a great circle tilted to the meridian. The effects of the collimation error of the instrument are eliminated by reversal of the instrument during the observation. Hence, half of the transit is observed early (or late) and the other half observed late (or early) by an equal amount and the mean of the two halves is free of the effects of the collimation error.

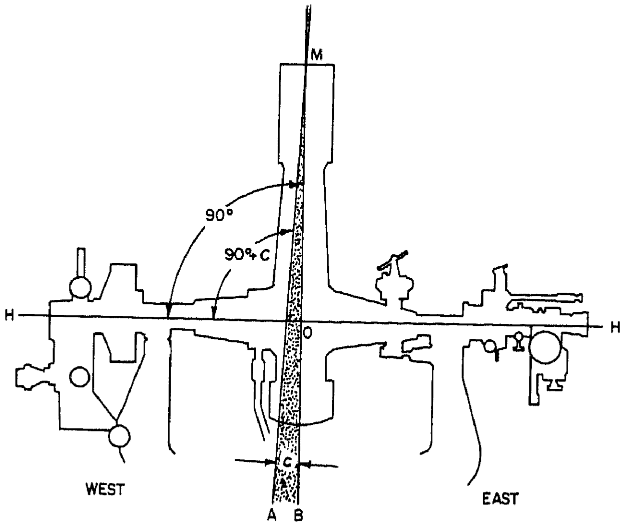


Figure 6-19. Collimation error.

(2) The same effect as collimation error exists in the observations with the eyepiece micrometer; however, they are not eliminated by reversal. The collimation error affects the observed transit time of the stars. Therefore a factor is required to reduce this error from the plane of the horizon to the plane of the equator. Figure 6-20 illustrates this factor and is given by the secant of the star's declination (sec δ). Therefore, in reference to the figure—

$C = \sec \delta$
$c =$ collimation error
$\theta =$ angular error, referenced to NCP
$C_c =$ total correction, reduced to equator.

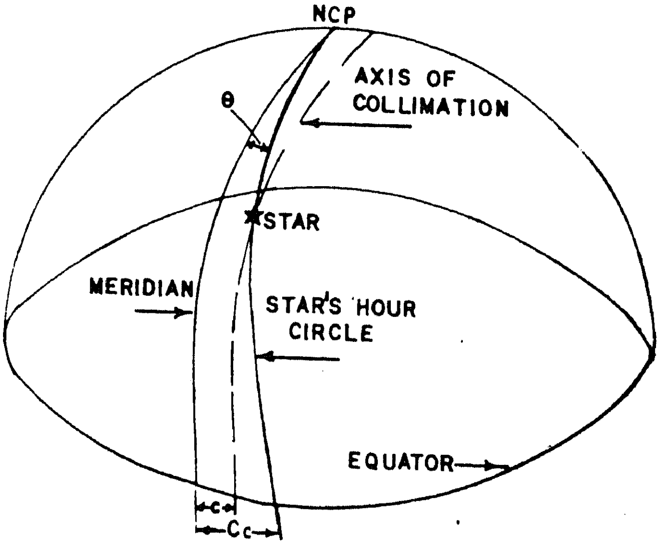


Figure 6-20. Effects of collimation error.

c. Correction for Eyepiece Micrometer. The determination of this correction has been discussed in paragraphs 3-7 through 3-10. The formula as shown in paragraph 3-10c is altered as follows, because the sec δ was defined to equal "C" ((2) above), hence the micrometer correction becomes—

$$\int = \tfrac{1}{2} R/100\ (m + s)\ C$$

d. Diurnal Aberration. This correction would be more properly applied to the apparent position of the star, but for sake of simplicity it is applied to the transit time.

(1) If the observer were perfectly stationary, in regard to the rotation of the earth, when pointing on a star the light rays from the star would enter the telescope at the objective end and emerge

at the eyepiece instantaneously. Since the earth is rotating, carrying the observer with it, and the latitude of the observer has a direct effect on his rotational speed, the observer must incline his telescope slightly in the direction of motion so that the light rays pass through the objective and strike the eyepiece in a straight line. This apparent displacement is known as aberration of light. There are two types; diurnal, the aberration due to the daily rotation of the earth, and annual aberration, which is due to the earth's orbital motion about the sun. Annual aberration is included in the values in the APFS and is not considered here.

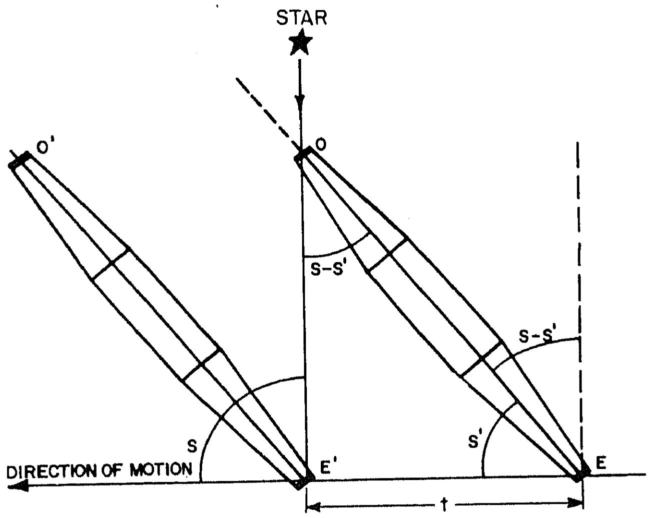


Figure 6–21. Effect of aberration.

(2) The effects of the diurnal aberration are graphically illustrated in figure 6–21, where:

$OE =$ position of the telescope when light from star strikes 0

$S =$ angle ray of light makes with direction of observer's motion

$S' =$ angle telescope makes with direction of observer's motion

$S - S' =$ angle of tilt in direction of motion that enables light rays to strike eyepiece when observer reaches position E′

$t =$ time required for observer to travel from E to E′

$EE' =$ tv, where v equals the velocity of the observer

$OE' =$ tc, where c equals the velocity of light

From triangle EE′0 with k′ equal to the aberration of light angle (S − S′)

$$\frac{\sin k'}{\sin S'} = \frac{EE'}{OE'} = \frac{v}{c}$$

Since k′ is very small we write sin k′ = k′ sin 1″ and sin S′ = sin S, we have:

$$k' = \frac{v}{c \sin 1''} \sin S$$

When applying diurnal aberration to observations, we find the velocity of the observer in kilometers per second equal to:

$$v = \frac{2\pi\, \rho \cos \phi}{24 \times 60 \times 60}$$

Where ρ equals the mean radius of the earth, 6,378 kilometers, and the ϕ is the latitude of the observer.

$$v \text{ or velocity of observer} = 0.464 \cos \phi$$

substituting in the first equation:

$$k' = \frac{0.464 \cos \phi}{300{,}000 \sin 1''} \sin S$$

Assuming sin S = sin S′ without the loss of accuracy we have:

$$k' = 0''.319 \cos \phi \text{ or } k' = 0^{s}.0213 \cos \phi$$

(3) In the application of diurnal aberration to longitude observations we have the relationship shown in figure 6–22.

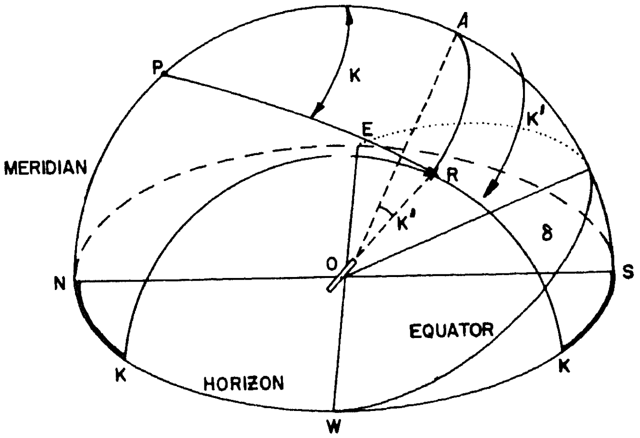


Figure 6–22. Diurnal aberration applied to longitude.

(4) To compensate for aberration, the telescope should be tilted in the direction of motion (west to east) by the amount k′. Since the telescope is in a fixed position with regards to the east-west motion, stars crossing the meridian are therefore observed late by the amount k, or the arc distance RA. From the law of sines in the spherical triangle PAR, and keeping in mind that the polar distance PR is equal to 90° − δ we have:

$$\frac{\sin k}{\sin k'} = \frac{\sin 90^\circ}{\sin (90^\circ - \delta)}$$

Since k and k′ are very small angles, we may write, $k = k' \sec \delta$

Substituting, we have:

$$k = 0^{s}.0213 \sec \delta \cos \phi$$

and from previous determination "C" = sec δ, we may finally state:

$$k = 0^{s}.0213 \cos \phi\, C$$

e. Azimuth Factor. The effect of the azimuth factor has been explained in paragraph 5-4*b*. Although the azimuth factor is not utilized on this computation sheet, it is computed and entered at this time as the factors necessary for its computation are included on this form.

6-17. Corrected Transit Time

The correction for instrument errors and aberration applied to the scaled transit time will now give the transit time uncorrected for chronometer error:

$$t = (\text{scaled transit time}) + l - k + Bb$$

6-18. Chronometer Correction for Any Star

After the difference between the assumed local sidereal time and the chronometer time has been computed and the rate determined (para. 6-14), the chronometer correction (Δt) for any star may now be computed. Time and Δt for the first radio-chronometer comparison are respectively: $20^{h}\ 14^{m}\ 26^{s}.482$ and $+\ 05^{s}.583$. For the next radio-chronometer comparison they are: $21^{h}\ 09^{m}\ 15^{s}.450$ and $+\ 05^{s}.595$. The rate is $+0^{s}.000219$ per minute. Star 765 has a scaled transit time of $20^{h}\ 20^{m}\ 58^{s}.070$. The difference between transit time and the prior radio-chronometer comparison is therefore $06^{m}.543$. Then:

$$\begin{aligned}\Delta t &= +\ 05^{s}.583 + (06.543)\,(+\ 0^{s}.000219)\\ &= 05^{s}.583 + (+\ 0^{s}.001) = +\ 05^{s}.584\end{aligned}$$

The chronometer correction for any star may be computed when the transit time has occurred between two radio-chronometer comparisons.

6-19. Computation of Right Ascension

a. The apparent right ascension is obtained from the APFS for stars observed for longitude. Epoch type catalogs may be used, but their use is recommended for electronic computers.

b. The APFS is a catalog of the "10 day star" type; i.e., the positions are given for every 10th day referenced to the FK4 system. This actually gives the apparent place for every 10th upper transit or every 9.973 solar days.

c. The meridian of reference in the APFS is the meridian of 0° or the Greenwich meridian. If the observer were at a longitude of 0° the right ascension at *upper transit* of any star on any day could easily be interpolated by a fractional part of 10. When an observer is on a meridian other than the Greenwich meridian his longitude becomes part of the interpolation argument when apparent position at *upper transit* is desired.

d. Example: an observer with a longitude of 77° W desires to determine the right ascension at *upper transit* of star 765 on the local date 18 Jul 68. Apparent right ascension at upper transit of the Greenwich meridian is listed for 12.0 Jul 68 and 22.0 Jul 68. If upper transits were made at 12.0 and 22.0 UT they were also made at 12.0 and 22.0 local mean time. Between 12.0 Jul and 22.0 Jul there were 10 upper transits, therefore when referred to Greenwich the interpolating argument is approximately 6/10, but when referred to the meridian of the observer the star has moved 0.214 day (77°) past the upper transit of the Greenwich meridian. The argument therefore becomes $(6.0 + 0.214)/9.973$ or $6.214/9.973 = 0^{d}.623$, and this value is usually denoted by "η". In the eastern hemisphere the longitude in decimal parts of a day is negative in the interpolating argument.

e. Since 10ths of days are included in the dates only to avoid confusion and the interval is always 10, the 10ths of days may be dropped in the reduction. The functions of right ascension and declination are neither linear nor simple algebraic curves but are very complex. The values of the differences vary constantly in amount and sign. A simple interpolation (linear interpolation) is not sufficiently accurate, therefore the method of interpolation with respect to second differences (Besselian interpolation) is used. The second difference correction is given by:

$$\mathrm{B}''\ (\Delta_0'' + \Delta_1'')$$

Where:

B'' = the interpolating argument and is a function of the interpolating argument (η) of the linear interpolation
$(\Delta_0'' + \Delta_1'')$ = the sum of the second differences

The interpolating argument is computed from the expression:

$$B'' = \frac{\eta\ (\eta - 1)}{4}$$

Where:

η = the interpolating argument for the first difference

Using the "η" determined in *d* above we have:

$$B'' = \frac{0.623\ (0.623 - 1.0)}{4} = -\ 0.059$$

The sign of the correction is opposite in sign to the sum of the second differences. An example of the determination of right ascension (α) at upper transit for one star is shown below.

Star 765

	Argument		Function	Differences 1st	 2d
	Jul 2.1		$20^{h}\ 21^{m}\ 06^{s}.939$		
				+0.164	
	12.0		07.103		−0.050
9.973		6+0.214		+0.114	
	22.0		07.217		−0.054
				+0.060	
	31.9		07.277		

For upper transit at W05^h 08^m 36^s (+ 0.214 day) on 18 Jul 68:

$$\alpha = 20^h\,21^m\,07^s.103 + (0.623)(+0.114) + (-0.059)(-0.104)$$

$$\alpha = 20^h\,21^m\,07^s.103 + 0.071 + 0.006 = 20^h\,21^m\,07^s.180$$

6–20. Determination of the Mean Epoch of Observation

a. In many series of computations it is necessary to determine the universal time of an instant of observation. The first differences of the functions given in a star catalog are in some cases small enough that, rather than having to reduce each observation to UT, a "mean epoch" is assumed as the argument for a series of observations. These instances occur in the determination of such values as short period terms of nutation and Besselian Day numbers.

b. An approximate mean epoch may be assumed, without loss of accuracy, for all observations made during a period of 4 hours or less. When the period exceeds 4 hours or there are long periods of inactivity during the observation period, more than one mean epoch is assumed.

(1) The problem to be solved is the conversion of a local sidereal time to a Universal Time, expressed in days and fractions thereof. Whenever stars are observed on the meridian, right ascension of these stars may be substituted for the sidereal time read from the chronometer. Whenever stars not on the meridian are observed the corrected chronometer time must be used.

(2) Consider a series of meridian transit observations in which the right ascension of the first observed star is 11^h 03^m 05^s, the right ascension of the last observed star is 12^h 57^m 43^s; the observer's longitude is 10^h 20^m 37^s E, and the local date is 25 Mar 68. The approximate mean epoch of this series of observations, in sidereal time, is the mean of the right ascension of the first and last observed star in the set.

(3) The same is true in the case of a series of observations made on a single star, in which, for example, the local sidereal time of the first observation is 11^h 03^m 05^s on 25 Mar 68 and the local sidereal time of the last observation is 12^h 57^m 43^s on 25 Mar 68; here again the approximate mean epoch is 12^h 00^m 24^s on 25 Mar 68.

c. The longitude difference, in time, is added (if west of Greenwich) or subtracted (if east of Greenwich) to the mean epoch and the result is the Greenwich Sidereal Time of the mean epoch. The Greenwich date can usually be deduced. The sidereal time of 0^h UT for the Greenwich date is subtracted from the Greenwich Sidereal Time to give the sidereal interval. Dividing this by 24^h.006 or 1444^m gives the decimal part of the Greenwich Civil day.

Mean epoch in sidereal time	20^h	41^m	58^s	18 Jul 68 am
Reduction to Greenwich ($\Delta\lambda$)	5	08	36	
Greenwich Sidereal Time	25	50	34	
Sid time 0^h UT 18 Jul 68 (—)	19	43	27	
Sidereal interval	06	07	07	
Conversion to solar time:	$\frac{06^h.110}{24.066}$ or $\frac{367^m.12}{1444} = 0^d.254$			
Greenwich Civil day of mean epoch:				18.254 Jul 68

d. As a check on the correct Greenwich Civil Day the problem is then worked in reverse i.e., using the UT of the mean epoch the local sidereal time is determined; if the LST thus computed is not within 45 seconds of the local sidereal time of the mean epoch an error has been made. If the difference is about 4 minutes the wrong Greenwich day was chosen and the problem must be reworked from the Greenwich Sidereal Time, using the proper Greenwich day and hence a new sidereal time at 0^h.

6–21. Computation of Short Period Terms of Nutation in Right Ascension ($\Delta\alpha$)

a. Precession and all long period terms of nutation are included in the values of the apparent places given in the APFS. Short period terms of nutation must be computed for each star from the expression:

$$\Delta\alpha = d\alpha(\psi)\,d\psi + d\alpha(\varepsilon)\,d\varepsilon$$

The values of "$d\alpha(\psi)$" and "$d\alpha(\varepsilon)$" are constants for each star and are listed at the bottom of the columns of the apparent places. The values of "$d\psi$" and "$d\varepsilon$" are tabulated in table I. APFS, with 0^h UT as the argument.

b. A mean epoch of observation, as a Greenwich civil day, is determined and used to interpolate the values of "$d\psi$" and "$d\varepsilon$". A determination of the short period terms of nutation is as follows:

Greenwich civil day of the mean epoch: 18.254 Jul 68

	$d\psi$	$d\varepsilon$	
Tabular value Jul 18	$-0^s.143$	$+0^s.050$	
Argument 18.254	-0.153	$+0.040$	Interpolated Values
Tabular value Jul 19	-0.182	$+0.009$	

For star 765 at upper transit on 18 Jul 68;

$$\Delta\alpha = (+.043)(-.153) + (-.032)(+.040) = (-.0066) + (-.0013) = -0^s.008$$

Short period terms of nutation should be accumulated on the desk calculator at the same time that right ascension is computed.

6-22. Computation of $(\alpha - t)$

The value of $(\alpha - t)$ for each star is arrived at by the solution of the formula:

$$(\alpha - t) = \alpha + \Delta\,\alpha - (t + \Delta t)$$

After all the $(\alpha - t)$'s have been computed, an inspection will reveal any inconsistency from the standpoint of sign and/or value. When the assumed longitude has been very close to the astronomic longitude, the sign of $(\alpha - t)$ may vary. However, this variation is small. Any large variation in the value should make a star suspect. A common error of 30^s results from an incorrect mean of the star transits when a change of the minutes has taken place and was not included in finding the mean. A completed $(\alpha - t)$ page is shown in figure 6-23.

6-23. Least Squares Adjustment of Longitude

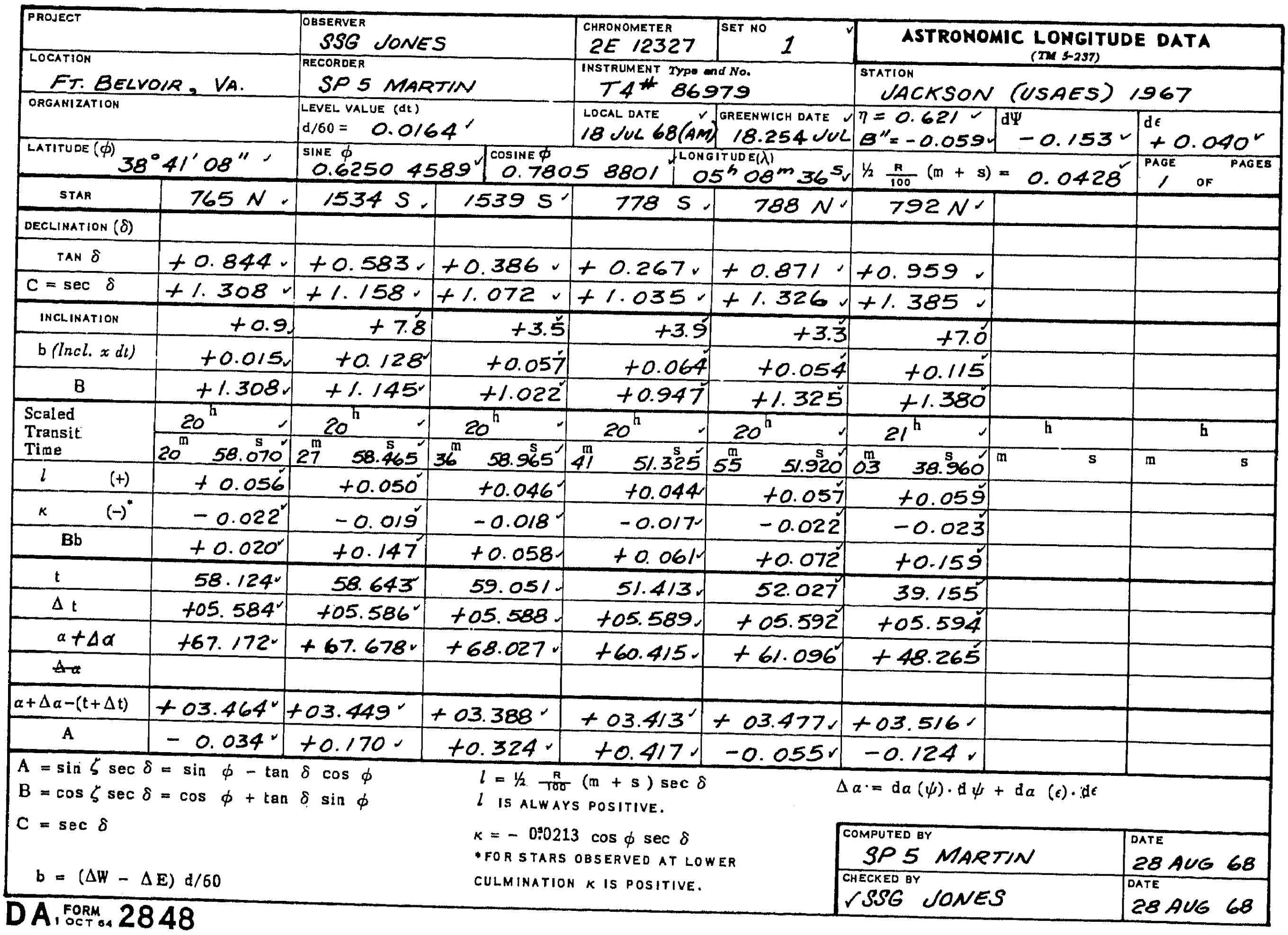
a. All stars are entered by set, in chronological order, with the corresponding $(\alpha - t)$ and "A" factor on a least squares adjustment sheet, DA Form 2849 (Least Squares Adjustment of Longitude) (fig. 6-24). If all $(\alpha - t)$'s are relatively large with the same algebraic sign, a constant may be added to each to bring them all close to zero. This procedure reduces computation effort for the least squares adjustment, but the constant must be subtracted from the final result.

b. Generally $(\alpha - t) = \Delta\lambda$, however there is an error remaining in the $\Delta\lambda$ for each star; this is the error caused by the instrument not being exactly in the meridian (a) and is given by the following expression:

Azimuth error $= a(\sin\phi - \tan\delta\cos\phi) = Aa$

Hence, the equation becomes $\Delta\lambda = Aa - (\alpha - t)$

c. The values of $\Delta\lambda$ and "a" are solved by the least squares method and the individual residuals



PROJECT
OBSERVER: SSG JONES
CHRONOMETER: 2E 12327
SET NO: 1

ASTRONOMIC LONGITUDE DATA
(TM 5-237)

LOCATION: FT. BELVOIR, VA.
RECORDER: SP 5 MARTIN
INSTRUMENT Type and No.: T4# 86979
STATION: JACKSON (USAES) 1967
ORGANIZATION
LEVEL VALUE (dt) d/60 = 0.0164
LOCAL DATE: 18 JUL 68 (AM)
GREENWICH DATE: 18.254 JUL
η = 0.621
B'' = -0.059
dΨ: -0.153
dϵ: +0.040
LATITUDE (ϕ): 38°41'08"
SINE ϕ: 0.6250 4589
COSINE ϕ: 0.7805 8801
LONGITUDE (λ): $05^h\,08^m\,36^s$
½ $\frac{R}{100}$ (m + s) = 0.0428
PAGE 1 OF PAGES

STAR	765 N	1534 S	1539 S	778 S	788 N	792 N		
DECLINATION (δ)								
TAN δ	+0.844	+0.583	+0.386	+0.267	+0.871	+0.959		
C = sec δ	+1.308	+1.158	+1.072	+1.035	+1.326	+1.385		
INCLINATION	+0.9	+7.8	+3.5	+3.9	+3.3	+7.0		
b (*Incl. x dt*)	+0.015	+0.128	+0.057	+0.064	+0.054	+0.115		
B	+1.308	+1.145	+1.022	+0.947	+1.325	+1.380		
Scaled Transit Time	20^h	20^h	20^h	20^h	20^h	21^h	h	h
	$20^m\ 58.070^s$	$27^m\ 58.465^s$	$36^m\ 58.965^s$	$41^m\ 51.325^s$	$55^m\ 51.920^s$	$03^m\ 38.960^s$	m s	m s
l (+)	+0.056	+0.050	+0.046	+0.044	+0.057	+0.059		
κ (−)*	−0.022	−0.019	−0.018	−0.017	−0.022	−0.023		
Bb	+0.020	+0.147	+0.058	+0.061	+0.072	+0.159		
t	58.124	58.643	59.051	51.413	52.027	39.155		
Δ t	+05.584	+05.586	+05.588	+05.589	+05.592	+05.594		
$\alpha + \Delta\alpha$	+67.172	+67.678	+68.027	+60.415	+61.096	+48.265		
~~$\Delta\alpha$~~								
$\alpha+\Delta\alpha-(t+\Delta t)$	+03.464	+03.449	+03.388	+03.413	+03.477	+03.516		
A	−0.034	+0.170	+0.324	+0.417	−0.055	−0.124		

A = sin ζ sec δ = sin ϕ − tan δ cos ϕ
B = cos ζ sec δ = cos ϕ + tan δ sin ϕ
C = sec δ

b = (ΔW − ΔE) d/60

$l = ½\,\frac{R}{100}\,(m + s)\sec\delta$
l IS ALWAYS POSITIVE.

$\kappa = -\,0.^s0213\,\cos\phi\,\sec\delta$
*FOR STARS OBSERVED AT LOWER CULMINATION κ IS POSITIVE.

$\Delta\alpha = d\alpha(\psi)\cdot d\psi + d\alpha(\epsilon)\cdot d\epsilon$

COMPUTED BY: SP 5 MARTIN — DATE: 28 AUG 68
CHECKED BY: ✓SSG JONES — DATE: 28 AUG 68

DA FORM 1 OCT 64 2848

Figure 6-23. Computation of $(\alpha - t)$.

LEAST SQUARES ADJUSTMENT OF LONGITUDE
(TM 5-237)

SET NO. 1.

PROJECT

LOCATION FT. BELVOIR, VA.

STATION JACKSON (USAES) 1967

OBSERVER SSG JONES

INSTRUMENT *(Type and No.)* T4 # 86979

CHRONOMETER 2E 12327

DATE 18 JUL (AM) 68

STAR	A	$\alpha+\Delta\alpha-t-\Delta t$	AA	$A(\alpha+\Delta\alpha-t-\Delta t)$	Aa	$\Delta\lambda$	V
765 N	−0.034	+03.464			+0.006	−3.458	−0.015
1534 S	+0.170	+03.449			−0.032	−3.481	+0.008
1539 S	+0.324	+03.388			−0.061	−3.449	−0.024
778 S	+0.417	+03.413			−0.079	−3.492	+0.019
788 N	−0.055	+03.477			+0.010	−3.467	−0.006
792 N	−0.124	+03.516			+0.023	−3.493	+0.020
Σ =	+0.698	+20.707	+0.3273	+2.3623	Σ =	−20.8400	+0.002
					MN =	−3.47333	

$$6.00000\Delta\lambda - 0.69800a + 20.70700$$

$$+0.11633a - 3.45117 = \Delta\lambda$$

$$+0.32730a - 2.36230$$

$$-0.08120a + 2.40892$$

$$+0.24610a + 0.04662 = 0$$

$$a = -0.18944$$

$$\Delta\lambda = -3.47321$$

NORMAL EQUATIONS

$$n\Delta\lambda - [A]a + [(\alpha+\Delta\alpha-t-\Delta t)] = 0$$

$$-[A]\Delta\lambda + [AA]a - [A(\alpha+\Delta\alpha-t-\Delta t)] = 0$$

COMPUTED BY SP 5 MARTIN

DATE 28 AUG 68

CHECKED BY ✓ SSG JONES

DATE 28 AUG 68

DA FORM 1 OCT 64 2849

Figure 6–24. Least squares adjustment of longitude.

are then computed for each star in the set. For rejection criteria, see paragraph 6–2*a*(9).

d. The normal equations for the solution of $\Delta\lambda$ and "a" are—

$$n\,\Delta\lambda - [A]\,a + [(\alpha - t)] = 0 \text{ and}$$

$$-[A]\Delta\lambda + [AA]\,a - [A(\alpha - t)] = 0$$

Where "n" is the number of stars in the set. By substituting known quantities in the first equation and solving for $\Delta\lambda$ in terms of the known values and "a", and by substituting that term of $\Delta\lambda$ into the second formula, the value of "a" is solved. Then substituting the known value of "a" into the first formula the value of $\Delta\lambda$ for the set is solved. The value of "a" for the set should not exceed $\pm 1\overset{s}{.}00$. After multiplying "a" for the set by the individual "A" factor, the individual $\Delta\lambda$, as determined by each star, is computed from the formula:

$$\Delta\lambda = Aa - (\alpha - t)$$

The probable error of the mean of the set may be computed from the standard formula:

$$e_m = \pm 0.6745\sqrt{\frac{[vv]}{n(n-1)}}$$

6–24. Final Longitude Computation

a. The observation sets are abstracted on to DA Form 1962 (Tabulation of Geodetic Data) (fig. 6–25). The probable error of the mean longitude "e_λ" is computed from the standard formula. See paragraph 6–2 for allowable P.E.'s.

b. The observed $\Delta\lambda$, audio filter lag, transmission time lag, and the time signal error (if these were not included in the radio-chronometer comparison) are added to the assumed longitude (from DA Form 2848). The sum is the astronomic longitude of the station referenced to the instantaneous pole of the earth. See paragraph 6–14*c* for correction to signal.

6–25. Transmission Time Lag

a. Since it requires a definite amount of time for a radio signal to travel from one point on earth to another, the time when the radio signal is received is somewhat later than when it was transmitted. The interval is not large, as the theoretical velocity of a radio wave in standard atmosphere is approximately 300,000 km per second. The published time signals are emission times, i.e., the transmission time lag with respect to the observatory has been removed from the published values, but the time required for the signal to arrive at the astronomic station must be applied to the observed longitude.

b. The arc distance between the transmitting station and the astronomic station may be computed from the formula:

$$\cos D = (\sin\phi_1)(\sin\phi_2) + (\cos\phi_1)(\cos\phi_2)(\cos\Delta\lambda)$$

Where:

D = the great circle distance in arc units between the stations

ϕ = the respective latitudes of the stations

$\Delta\lambda$ = the difference in longitude of the stations, never exceeds 180°

c. The correction to the observed longitude in seconds of time is then given by:

$$\text{Trans Lag} = 0.000401D$$

The arc distance, D, is expressed in degrees and decimals thereof; for the correction in arc units use 0.006015D.

6–26. Audio Filter Lag

A finite amount of time is required for the time signal to pass through the radio receiver, audio filter, and the amplifier. The method and procedure for determining the lag are discussed in paragraph 4–9*b*. Any lag causes the radio signal to be late and is applied to the observed longitude.

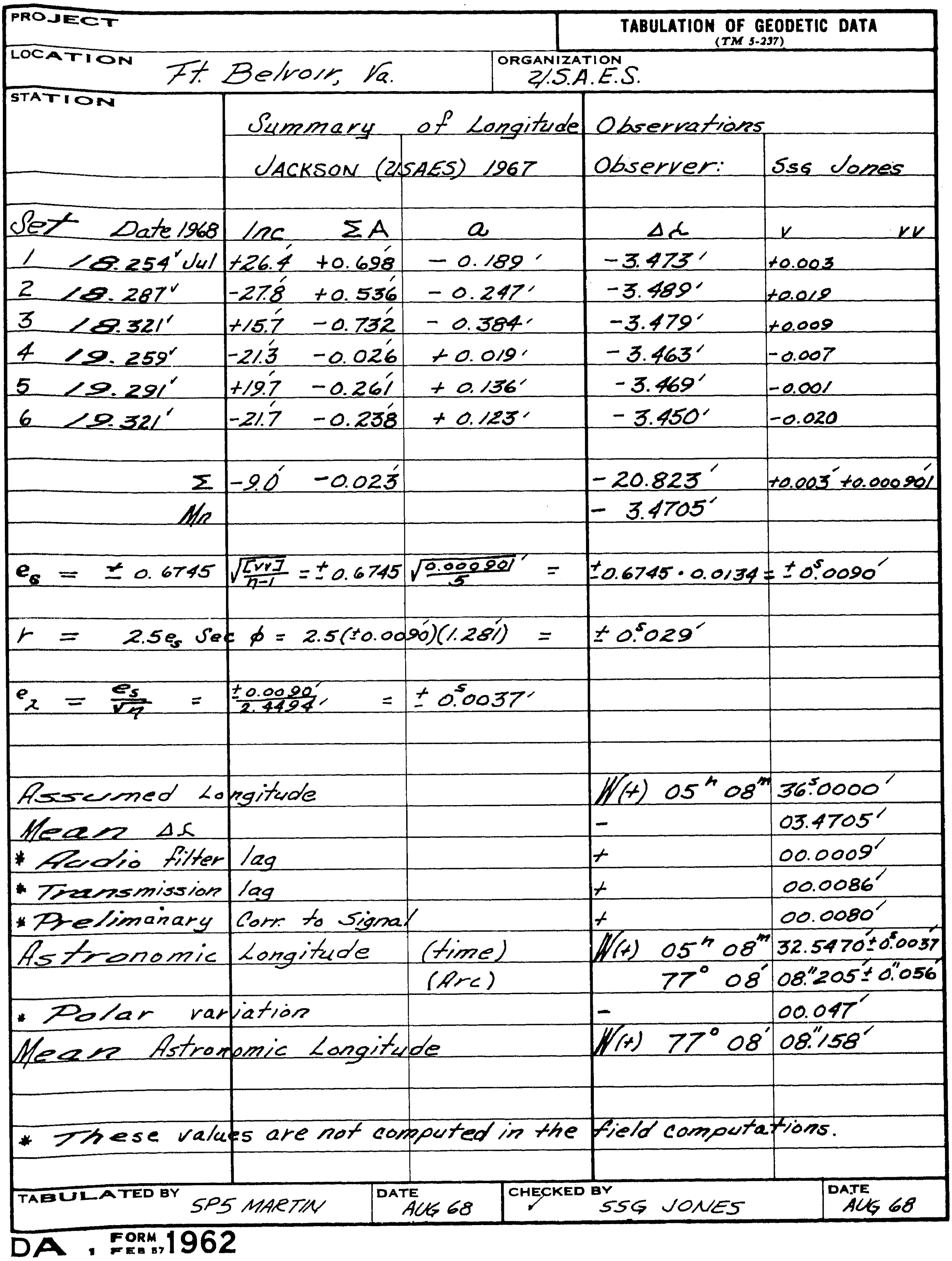
6–27. Pen Equation Application

When both the radio and transit eyepiece signals are fed through the same pen on the chronograph there is no correction for the pen equation. If they are on separate pens the linear difference as measured from the pen equation test must be converted to time units (considering the chart speed of the chronograph) and be applied to the longitude. The amount and sign of the correction may be determined by logic. The requirement for both a determination and application may be eliminated by judicious connection of the electrical timing equipment.

6–28. Polar Variation

a. The axis of the earth is not fixed. The direction and magnitude of the motion, having been observed for many years, are defined mathematically in terms of precession and nutation. However, after applying corrections for the annual, secular, and periodic terms there is still a small difference between the mathematically defined axis and the actual rotational axis. This difference is called the polar variation. The difference between the defined and actual axis may be observed as a movement of the terrestrial poles. It appears as a shifting in the latitude and longitude of the poles. The shift cannot as yet be precisely predicted and it appears to be somewhat random in nature. Although the shift never exceeds a very few tenths of a second of arc, its effect must be included in precise astronomic computations.

b. Certain observatories conduct special observa-



PROJECT

TABULATION OF GEODETIC DATA
(TM 5-237)

LOCATION Ft. Belvoir, Va.

ORGANIZATION U.S.A.E.S.

STATION

		Summary	of Longitude		Observations		
		JACKSON (USAES) 1967			Observer:	Ssg Jones	
Set	Date 1968	Inc	ΣA	a	Δλ	v	vv
1	18.254' Jul	+26.4'	+0.698'	− 0.189'	−3.473'	+0.003	
2	18.287'	−27.8'	+0.536'	− 0.247'	−3.489'	+0.019	
3	18.321'	+15.7'	−0.732'	− 0.384'	−3.479'	+0.009	
4	19.259'	−21.3'	−0.026'	+ 0.019'	− 3.463'	−0.007	
5	19.291'	+19.7'	−0.261'	+ 0.136'	− 3.469'	−0.001	
6	19.321'	−21.7'	−0.238'	+ 0.123'	− 3.450'	−0.020	
	Σ	−9.0'	−0.023'		−20.823'	+0.003'	+0.000901'
	Mn				− 3.4705'		
e_s =	± 0.6745	$\sqrt{\frac{[vv]}{n-1}} = \pm 0.6745$		$\sqrt{\frac{0.000901}{5}}'$ =	$\pm 0.6745 \cdot 0.0134 =$	$\pm 0^{s}.0090'$	
r =	2.5 e_s Sec	$\phi = 2.5(\pm 0.0090')(1.281')$		=	$\pm 0^{s}.029'$		
$e_\lambda = \frac{e_s}{\sqrt{n}}$ =		$\frac{\pm 0.0090'}{2.4494'}$		$= \pm 0^{s}.0037'$			
Assumed Longitude					W(+) 05ʰ 08ᵐ	36ˢ.0000'	
Mean Δλ					−	03.4705'	
* Audio filter		lag			+	00.0009'	
* Transmission		lag			+	00.0086'	
* Preliminary		Corr. to Signal			+	00.0080'	
Astronomic		Longitude		(time)	W(+) 05ʰ 08ᵐ	32.5470' ± 0ˢ.0037'	
				(Arc)	77° 08'	08".205 ± 0".056'	
* Polar variation					−	00.047'	
Mean Astronomic Longitude					W(+) 77° 08'	08".158'	

* These values are not computed in the field computations.

TABULATED BY	DATE	CHECKED BY	DATE
SP5 MARTIN	AUG 68	✓ SSG JONES	AUG 68

DA FORM 1 FEB 57 1962

Figure 6-25. Final longitude summary.

tions to determine the actual position of the pole. The position of the axis is then defined as a point on a rectangular grid at the North Pole. The center of this grid is the mathematically defined (mean) pole and the position of the instantaneous (actual rotational) pole given by "x" and "y" coordinates in seconds of arc. The positive direction of the "x" axis is southward along the Greenwich meridian and the positive direction of the "y" axis is southward along the meridian 90° West. Provisional values of the "x" and "y" coordinates are given in the Preliminary Times of Emission Circular published weekly by the US Naval Observatory (fig. 6–10). See paragraph 6–13*c* and figure 6–11 for information concerning time signal corrections.

c. The polar variation affects the observed latitude, longitude, and azimuth. Formulas for correcting latitude and azimuth observations are given in the appropriate chapters. The correction to longitude is given in seconds of arc by:

$$\Delta\lambda = -(x \sin\lambda - y \cos\lambda)\tan\phi$$

CHAPTER 7

DETERMINATION OF LATITUDE

Section I. STERNECK METHOD

7–1. Methods Used

At mid and low latitudes either the Sterneck or the Horrebow-Talcott methods of latitude observations may be used. At latitudes above 60° the scarcity of available stars may make these methods impractical; in this case the circum-meridian method may be used. Each method is described in a separate section of this chapter. In all methods the determination of latitude has the basic relationship of $\phi = \delta + \zeta$. At mid and low latitudes the Sterneck method is generally preferred due to easier preparation of the observing list and the less arduous computation. In the Sterneck method a qualified assistant observer is required to read the vertical bubble and vertical circle. An attachment has been developed by TOPOCOM which allows the observer to read the vertical bubble from the eyepiece end of the instrument, thereby eliminating the requirement for an assistant observer.

7–2. General

a. From the expression $\phi = \delta \pm \zeta$ the latitude of a station may be readily determined from the meridian zenith distance of a star of known declination. By using precise instruments and observing the meridian zenith distance of stars which are in the APFS, the astronomic latitude may be determined to a high degree of precision.

b. For observations to be acceptable as first order, the instrument used must have a vertical circle with an accuracy equal to that of a T–4 and a vertical circle level vial with a sensitivity of no more than 3″ per 2mm graduation.

7–3. Specifications

a. First Order.

(1) A valid determination consists of eight separate groups, each group consisting of eight or more star observations. Each group includes observations of a minimum of four stars north of the zenith and four stars south of the zenith.

(2) Observations are conducted on at least two nights with a minimum of three groups on any one night. It is permissible to observe all eight groups on one night if at least 4 hours separate the two observing periods.

(3) The zenith distance of any star shall not exceed 40° and preferably should not exceed 30°. Further, the sum of the zenith distances of the north stars should not exceed the sum of the zenith distances of the south stars by more than ± 10° and preferably not more than ± 5° for any group.

(4) Generally stars down to the 7th magnitude may be observed. Stars brighter than 3.0 in magnitude should be avoided or observed with a screen (filter).

(5) The vertical circle level vial shall be so leveled and centered that the summation of left minus right will approach zero for each group.

(6) The probable error of the mean latitude shall not exceed ± 0″.10. If the error of the mean exceeds this amount additional groups shall be observed.

b. Modified First Order. The methods, procedures, and specifications for modified first order are the same as first order except as noted.

(1) Four individual groups of eight stars are observed at each station.

(2) The observations may be completed in one observing period.

(3) The probable error of the mean result should not exceed ± 0″.30.

7–4. General Instructions for Observations

a. The instrument must be in the meridian within 3 seconds of time or better.

b. An observation list should be prepared that includes all available stars. The observation list will include most stars that are observed in longitude, hence it is common practice to include the Sterneck list with the longitude list. Those additional stars for Sterneck observation do not have the "A" factor listed (fig. 6–4).

c. An eye-ear radio chronometer comparison is made at the start of the observation, between each set (when necessary) and at the conclusion of observations. Values, as heard on the radio and read on the chronometer, are entered to the nearest 0ˢ.1 on the field record. Three consecutive observations of time should be made, i.e., read the chronometer at the start of a 5-minute period and twice more at identifiable minute pulses (para. 8–6). It is not necessary to take a radio-chronometer comparison between latitude sets unless there is a break of two hours or more.

d. The barometric pressure and dry bulb temperature are recorded at the start of observation, between each group and at the conclusion of observation. The altimeter should be calibrated before field use and set to indicate 300 m (or 1000 ft) at a pressure of 29″.92 hg. (See table B–16 for conversion of meter to inches or millimeters of hg.)

e. The vertical circle level vial must be accurately calibrated. The vial should be adjusted so that the two bubble ends are in coincidence at the number 7 graduation of the vial, and should be closely centered before bisecting the star. Sufficient time should be allowed (at least 30 seconds) for the bubble to settle before transit of the star occurs. It must not be leveled after the star has been observed nor before the circle is read. The final motion of the vertical level collimation screw should be clockwise (against the spring). If the summation of L-R for a group becomes too large (plus or minus) the level vial should be deliberately set to reduce the sum.

f. The eyepiece micrometer should be in the longitude position and the movable wire brought into coincidence with the center "10" wire. Being in the longitude position affords a quick changeover to longitude without refocusing.

g. Stars to be observed are usually selected so that a south star is observed after a north star, or vice versa. It is not desirable to observe more than two north stars, or two south stars, in succession. However, since it is more important to observe a group as rapidly as possible, this practice may be disregarded if it causes an excessive increase in observing time.

h. Groups shall be observed in such a manner that all stars of a group are observed in one circle position, i.e., left or right. The terms right and left refer to the location of the vertical circle when facing in the direction that the telescope is pointing. The only way to maintain this orientation throughout any one group is to observe all stars south of the zenith from one eyepiece position (east or west) and all stars north of the zenith from the opposite eyepiece position. The observer will note that by following the proper observing sequence both north and south stars appear on his right when in the circle left position and all stars appear on his left when in the circle right position. Equal numbers of groups are observed in circle left and circle right positions. The circle position is alternated between groups.

i. About 1½ minutes should be allowed between successive star transits when both stars are on the same side of the zenith. When the instrument must be reversed, i.e., a north star following a south star, about 2 minutes should be allowed.

7–5. Observing List

The observing list should be included with the longitude observing list. Only FK4 stars should be included. All stars with a zenith distance not exceeding 30° and a magnitude of 7.0 or brighter should be listed.

7–6. Observation Procedure

a. The observing party should include a minimum of three men; an observer to observe the star, an assistant observer to operate the vertical circle, and a recorder.

b. Before calling out the circle setting for a star the recorder must announce whether it is north or south of the zenith. This indicates to the observer whether he should be in ocular east or ocular west position for that star depending on whether he is observing the group circle left or circle right.

c. The observer notifies the recorder when the star appears in the telescope field of view. About 10 seconds before the star transit the observer informs the recorder to "standby". Using the vertical slow motion screw the observer bisects the star with the horizontal (the center of three closely spaced wires) wire. The last movement of the screw should be clockwise (against the spring). The bisection should be checked and corrected if necessary until the star crosses the vertical center wire. At the moment of transit the observer calls "tip".

d. The recorder estimates and records the chronometer time to the nearest 0ˢ.1.

e. After calling "tip" the observer should check the bisection, but never move the telescope. If the bisection is felt to be poor the observation is voided.

f. Without disturbing the instrument the assistant observer reads the vertical circle level vial, left end first, to the nearest 0.1 graduation. The assistant observer then reads the vertical circle to 0″.1. Two coincidences are read and recorded. The coincidences must agree within 0″.3.

7–7. Zenith Distance Record

All information must be entered correctly and fully in DA Form 5–69, (Horizontal Direction or

Angle Book) (fig. 7–1). The circle position, left or right, the vertical circle setting, the altimeter index, and temperature must also be recorded for each group. If the instrument has a vertical circle drive, the vertical circle setting should be as close to 00°00′00″.0 as possible. In the past it was assumed necessary to advance the vertical plates for every second set that was observed. However, through extensive observations by TOPOCOM this procedure was found to be unnecessary, because the stars observed will have different declinations and will be read at various positions on the vertical plates.

7–8. Latitude Computation

a. Use of Form. DA Form 3619-R (Latitude (Sterneck Method)) shown in figure 7–4 is used for the computation of the observed latitude for each group. DA Form 3619-R will be reproduced locally on 10½ x 8-inch paper (image size 9 8/10″ x 7″) (fig. 7–4a). The field data are checked and entered on the form.

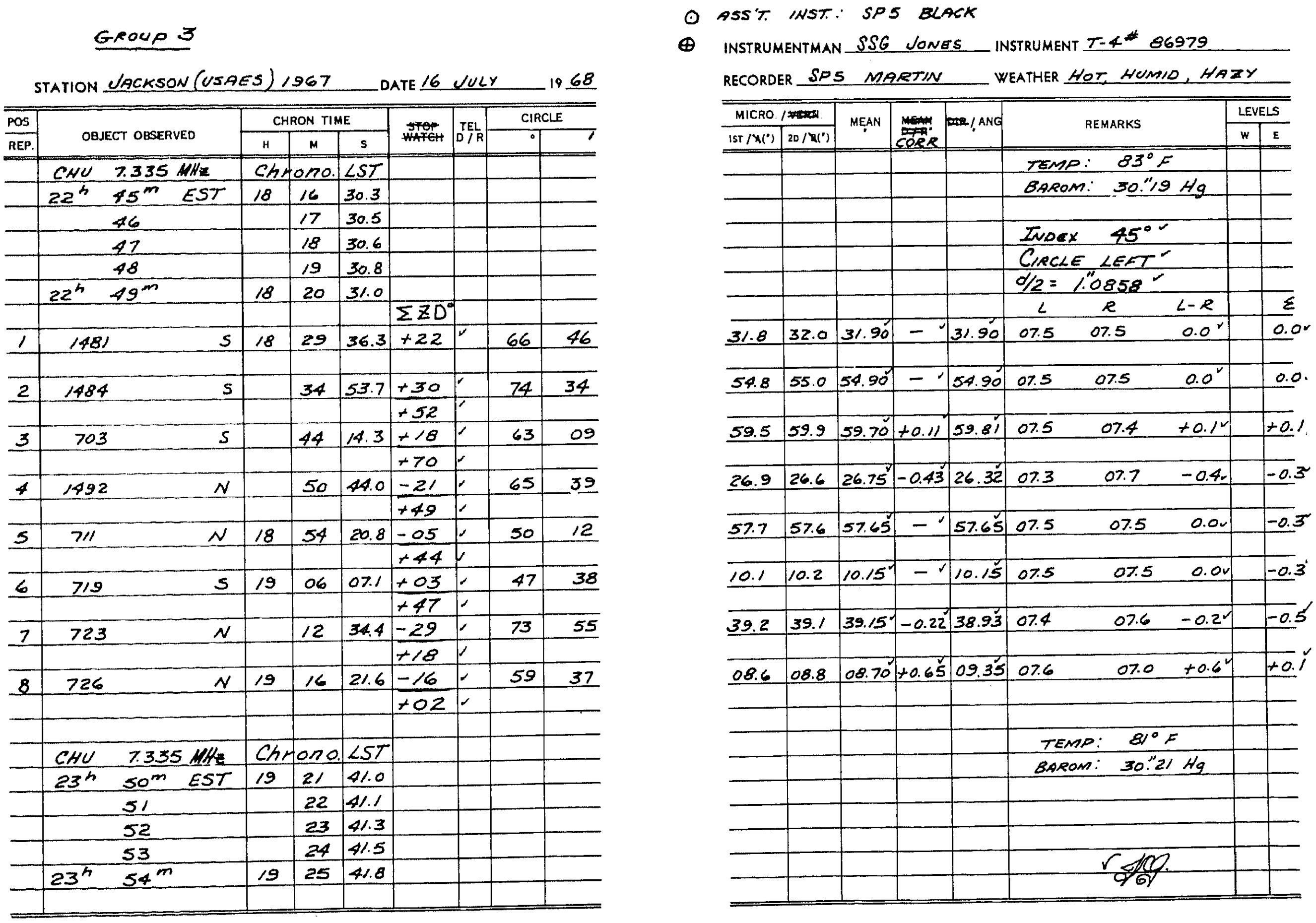
(1) The temperature and pressure reading preceding and following the group are meaned and entered in the heading.

(2) The chronometer correction should be determined and applied to the observed chronometer times before it is entered on the form. If the rate is large it should also be considered in the chronometer correction (para. 6–18).

(3) The vertical circle reading must be corrected in the record book for inclination before being entered on the form. One-half the level vial sensitivity, d/2, is multiplied by the dislevelment, L—R, for each observation and applied to the mean circle reading. After all circle readings have been entered, the observed zenith distance, ZD_0, is determined by subtracting the index correction (i.e., the vertical circle setting). If the group was observed circle right, the circle readings will actually be the explement of the zenith distance and they must be subtracted from 360°.

b. Refraction. Astronomic refraction is the apparent displacement of a celestial object caused by the bending of the light rays from the object as they pass through the atmosphere (fig. 7–2).

(1) The angular amount of displacement is the refraction correction. In figure 7–2 the light from star "S" is curved from "a" down to "0", and the observer at "0" sees the light apparently com-



GROUP 3

STATION JACKSON (USAES) 1967 DATE 16 JULY 19 68

POS REP.	OBJECT OBSERVED	CHRON TIME H	M	S	~~STOP WATCH~~	TEL D/R	CIRCLE °	′
	CHU 7.335 MHz	Chrono.		LST				
	22h 45m EST	18	16	30.3				
	46		17	30.5				
	47		18	30.6				
	48		19	30.8				
	22h 49m	18	20	31.0				
					ΣZD°			
1	1481 S	18	29	36.3	+22	✓	66	46
2	1484 S		34	53.7	+30	✓	74	34
					+52	✓		
3	703 S		44	14.3	+18	✓	63	09
					+70	✓		
4	1492 N		50	44.0	−21	✓	65	39
					+49	✓		
5	711 N	18	54	20.8	−05	✓	50	12
					+44	✓		
6	719 S	19	06	07.1	+03	✓	47	38
					+47	✓		
7	723 N		12	34.4	−29	✓	73	55
					+18	✓		
8	726 N	19	16	21.6	−16	✓	59	37
					+02	✓		
	CHU 7.335 MHz	Chrono.		LST				
	23h 50m EST	19	21	41.0				
	51		22	41.1				
	52		23	41.3				
	53		24	41.5				
	23h 54m	19	25	41.8				

⊙ ASS'T. INST.: SP5 BLACK

⊕ INSTRUMENTMAN SSG JONES INSTRUMENT T-4# 86979

RECORDER SP5 MARTIN WEATHER HOT, HUMID, HAZY

MICRO. / ~~VERN.~~ 1ST / ~~R~~(″)	2D / ~~R~~(″)	MEAN	~~MEAN DIFF.~~ CORR	~~DIR.~~ / ANG	REMARKS	LEVELS W	E
					TEMP: 83° F		
					BAROM: 30.″19 Hg		
					INDEX 45° ✓		
					CIRCLE LEFT ✓		
					d/2 = 1.″0858 ✓		
					L R L-R		Σ
31.8	32.0	31.90	—	31.90	07.5 07.5 0.0		0.0
54.8	55.0	54.90	—	54.90	07.5 07.5 0.0		0.0
59.5	59.9	59.70	+0.11	59.81	07.5 07.4 +0.1		+0.1
26.9	26.6	26.75	−0.43	26.32	07.3 07.7 −0.4		−0.3
57.7	57.6	57.65	—	57.65	07.5 07.5 0.0		−0.3
10.1	10.2	10.15	—	10.15	07.5 07.5 0.0		−0.3
39.2	39.1	39.15	−0.22	38.93	07.4 07.6 −0.2		−0.5
08.6	08.8	08.70	+0.65	09.35	07.6 07.0 +0.6		+0.1
					TEMP: 81° F		
					BAROM: 30.″21 Hg		

Figure 7–1. Zenith distance record (Sterneck).

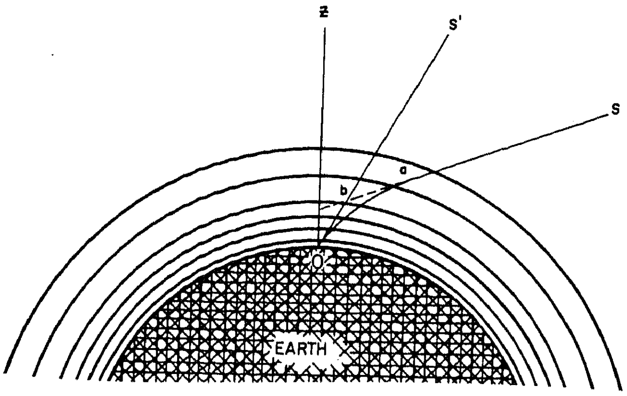


Figure 7-2. Astronomic refraction.

ing from "S′", along the line "b0". The star will thus appear at a greater altitude than it really is. Thus the difference between the direction of "S" and "S′" is the correction which must be applied to the apparent zenith distance to obtain the true zenith distance.

(2) Whenever a ray of light passes from rare air to a dense medium air (in this case from vacuum into air), bending of light rays takes place. Refraction begins at the upper limits of the atmosphere and increases proportionally as the density increases from the outer edge of the atmosphere down to the earth's surface. The density of air also depends on its temperature and the amount of water vapor contained in it.

(3) The density layers of the atmosphere are assumed to be parallel to the earth's surface when they are actually inclined at various unknown slopes. To reduce error caused by this assumption, zenith distances, north and south, must be closely balanced.

(4) The refraction correction (r_m), to the observed zenith distance is obtained from table B-3, appendix B. This mean refraction is then corrected by the coefficients for air temperature and atmospheric pressure from tables B-4 and B-5, appendix B. The corrected refraction is added to the observed zenith distance.

c. Zenith Distance. Computation of the corrected zenith distance for star #703 is as follows:

Mean circle reading $63^\circ\ 09'\ 59''.70$
(DA Form 5-69)
Inclination $= L\text{–}R\left(\frac{d}{2}\right) = +\,0.''11$
(DA Form 5-69)
Corrected circle reading $= 63^\circ\ 09'\ 59''.81$
Index correction $= 45^\circ$
$ZD_0 = +\,18^\circ\ 09'\ 59''.81$
Mean refraction $= 19''.00$, Temp $= 82^\circ$ F.,
Pres. $= 30''.20$ hg
$C_B = 1.010,\ C_T = 0.941,\ C_{BT} = 0.950$

Refraction correction $= 19''.00 \times 0.950$
$= +\,18''.05$
Corrected $ZD = 18^\circ\ 10'\ 17''.86$

d. Star Reduction. The mean epoch, constants, right ascension, and declination are computed as explained in paragraphs 6-20 through 6-22. In this case the right ascension need be correct only to the nearest 0ˢ.1 hence short period terms of nutation and diurnal aberration are not significant. The declination must be accurately computed and the short period terms of nutation in declination must be included. There is no diurnal aberration in declination of a star on the meridian. The same formula is used to compute the declination (δ) from the APFS as was used for right ascension, with a change in terms only, hence:

$$\delta = \delta' + \eta\,(1st\,\Delta) + B''(2d\,\Delta) + d\delta\,\psi\,(d\,\psi) + d\,\delta_\epsilon\,(d\,\epsilon)$$

e. Meridian Reduction. In the Sterneck method the star may be observed *off* the meridian, with the horizontal wire, while the instrument remains *in* the meridian. In the case of an observation when the star is off the meridian a correction must be applied to the observed zenith distance to reduce it to a meridian zenith distance (fig. 7-3).

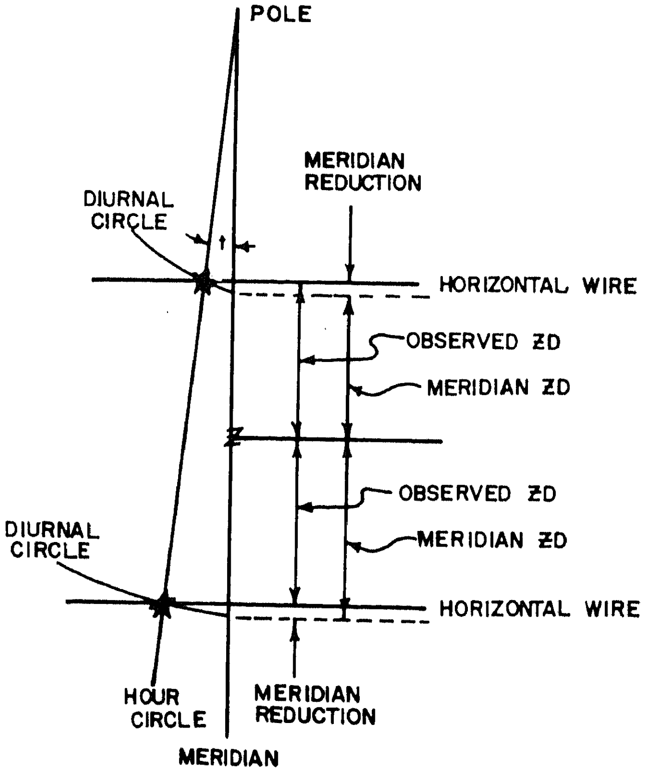


Figure 7-3. Meridian reduction.

(1) The correction is a function of the star's hour angle and declination. To determine the hour angle ($\alpha - t$) subtract from the star's right as-

cension its chronometer time of transit; this is a close approximation of the true meridian distance. The corrected chronometer time should be used but as the value of the meridian distance is not critical for small meridian distances, approximations may be used. A very close approximation of the true meridian distance may now be made by finding the mean "$\alpha - t$", excluding those not observed on the meridian, changing the sign of the mean "$\alpha - t$" and subtracting this value from all of the individual "$\alpha - t$'s".

(2) The correction, m, is given by:

$$m = \frac{\sin^2 \frac{1}{2} \tau}{\sin 1''} (\sin 2\delta)$$

Where:

τ = the local hour angle of the star

δ = the declination of the star

The expression "sin 2δ" is called a double angle formula and is equal to 2 sin δ cos δ. The correction is tabulated in table B-6, appendix B. The tabular value from this table must be multiplied by 2 to give the total correction.

(3) Since the instrument does remain in the meridian, if a star is observed off the meridian, the corrections to the observed zenith distance, ZD_0, are applied in the following manner: The observed zenith distance is *decreased* numerically if the star is near the upper transit between the observer's zenith and the elevated pole, or if the star is on the opposite side of the equator from the observer's zenith. The observed zenith distance is *increased* numerically if the star is near upper transit between the observer's zenith and the celestial equator, or if the star is near lower transit.

(4) If the star's meridian distance is less than ± 6ˢ the correction to the zenith distance will be negligible.

f. Computation of the Latitude. (fig. 7-4).

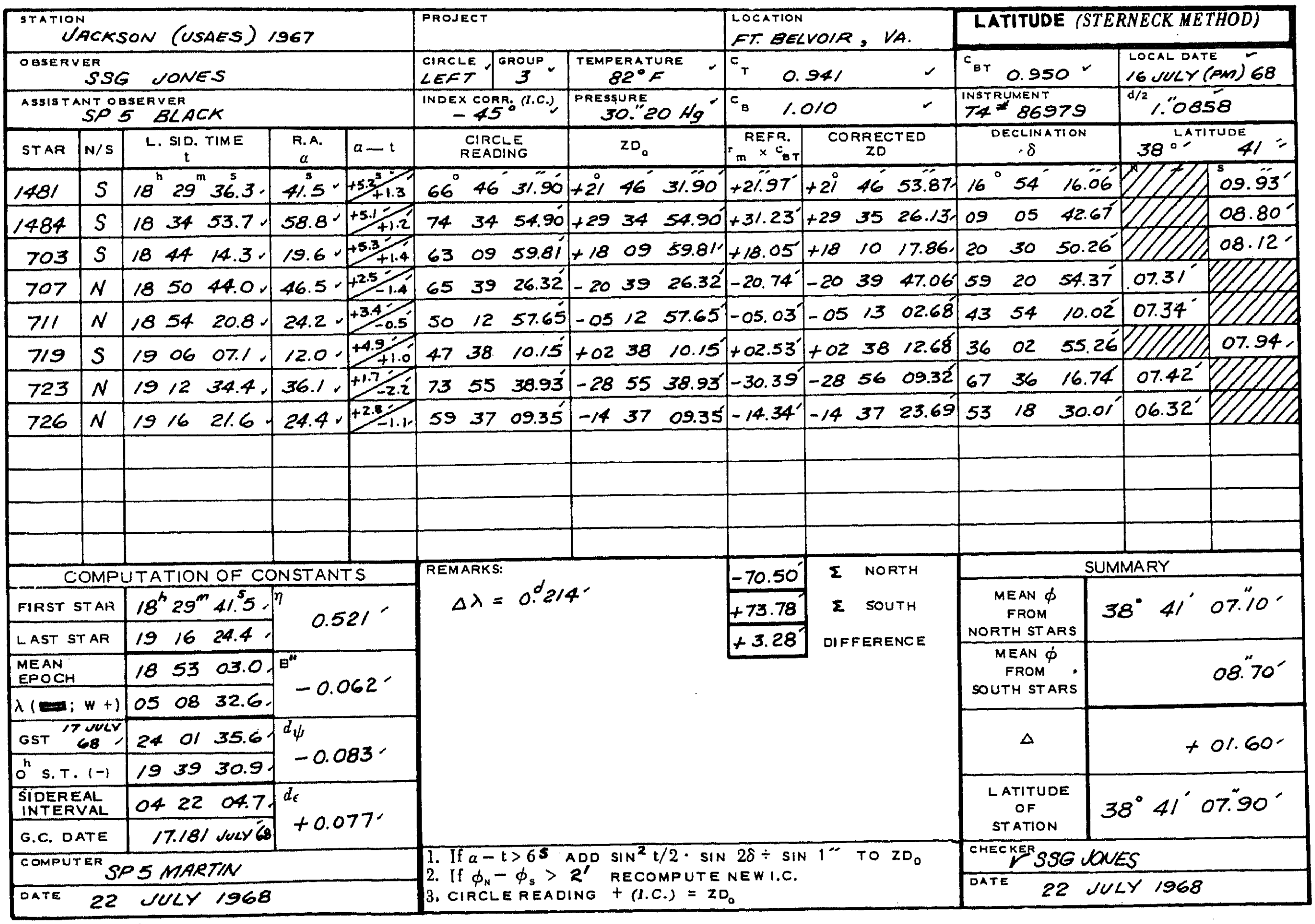
(1) The observed latitude for each star is determined from—

$\phi = \delta - ZD$, for stars north of the zenith

$\phi = \delta + ZD$, for stars south of the zenith

$\phi = 180° - (\delta + ZD)$, for subpolar stars

(2) The mean latitude as determined by ob-



LATITUDE *(STERNECK METHOD)*

STATION JACKSON (USAES) 1967

PROJECT

LOCATION FT. BELVOIR, VA.

OBSERVER SSG JONES

CIRCLE LEFT

GROUP 3

TEMPERATURE 82° F

C_T 0.941

C_{BT} 0.950

LOCAL DATE 16 JULY (PM) 68

ASSISTANT OBSERVER SP 5 BLACK

INDEX CORR. (I.C.) − 45°

PRESSURE 30.″20 Hg

C_B 1.010

INSTRUMENT 74 # 86979

d/2 1.″0858

STAR	N/S	L. SID. TIME t	R.A. α	α — t	CIRCLE READING	ZD₀	REFR. $r_m \times C_{BT}$	CORRECTED ZD	DECLINATION δ	LATITUDE 38° 41′ N	S
1481	S	18ʰ 29ᵐ 36.3ˢ	41.5ˢ	+5.2ˢ +1.3	66° 46′ 31.90″	+21° 46′ 31.90″	+21.97″	+21° 46′ 53.87″	16° 54′ 16.06″	▨	09.93″
1484	S	18 34 53.7	58.8	+5.1 +1.2	74 34 54.90	+29 34 54.90	+31.23	+29 35 26.13	09 05 42.67	▨	08.80
703	S	18 44 14.3	19.6	+5.3 +1.4	63 09 59.81	+18 09 59.81	+18.05	+18 10 17.86	20 30 50.26	▨	08.12
707	N	18 50 44.0	46.5	+2.5 −1.4	65 39 26.32	−20 39 26.32	−20.74	−20 39 47.06	59 20 54.37	07.31	▨
711	N	18 54 20.8	24.2	+3.4 −0.5	50 12 57.65	−05 12 57.65	−05.03	−05 13 02.68	43 54 10.02	07.34	▨
719	S	19 06 07.1	12.0	+4.9 +1.0	47 38 10.15	+02 38 10.15	+02.53	+02 38 12.68	36 02 55.26	▨	07.94
723	N	19 12 34.4	36.1	+1.7 −2.2	73 55 38.93	−28 55 38.93	−30.39	−28 56 09.32	67 36 16.74	07.42	▨
726	N	19 16 21.6	24.4	+2.8 −1.1	59 37 09.35	−14 37 09.35	−14.34	−14 37 23.69	53 18 30.01	06.32	▨

COMPUTATION OF CONSTANTS

FIRST STAR	18ʰ 29ᵐ 41.5ˢ	η 0.521
LAST STAR	19 16 24.4	
MEAN EPOCH	18 53 03.0	B″ − 0.062
λ ([redacted]; W +)	05 08 32.6	
GST 17 JULY 68	24 01 35.6	$d\psi$ − 0.083
0ʰ S.T. (−)	19 39 30.9	
SIDEREAL INTERVAL	04 22 04.7	$d\epsilon$ + 0.077
G.C. DATE	17.181 JULY 68	

COMPUTER SP 5 MARTIN

DATE 22 JULY 1968

REMARKS:

$\Delta\lambda = 0.^d214$

−70.50	Σ NORTH
+73.78	Σ SOUTH
+ 3.28	DIFFERENCE

1. If $\alpha - t > 6^s$ ADD $\sin^2 t/2 \cdot \sin 2\delta \div \sin 1''$ TO ZD_0
2. If $\phi_N - \phi_S > 2'$ RECOMPUTE NEW I.C.
3. CIRCLE READING + (I.C.) = ZD_0

SUMMARY

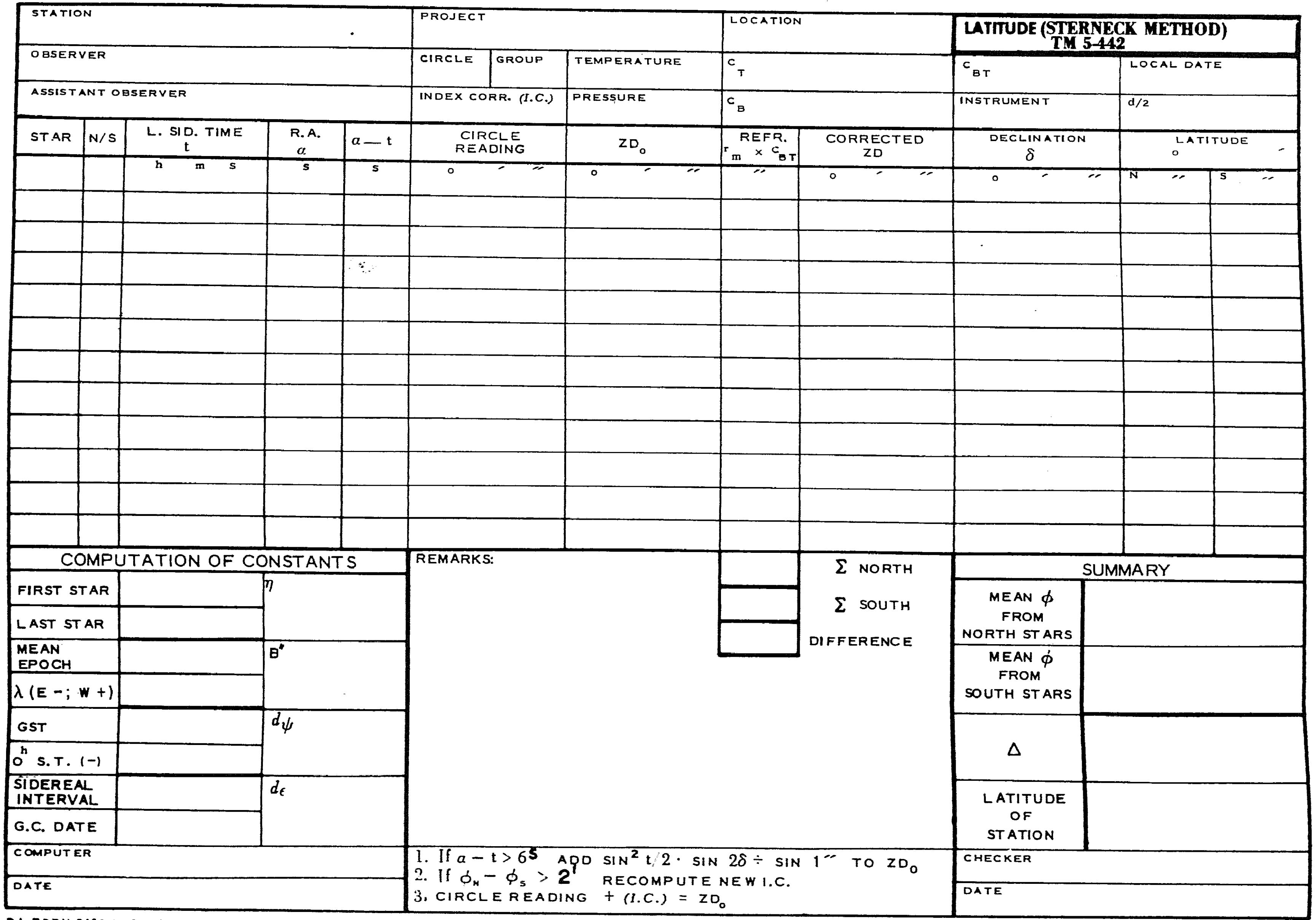
MEAN φ FROM NORTH STARS	38° 41′ 07.″10
MEAN φ FROM SOUTH STARS	08.″70
Δ	+ 01.60
LATITUDE OF STATION	38° 41′ 07.″90

CHECKER SSG JONES

DATE 22 JULY 1968

DA FORM 3619-R, 1 Jul 70

Figure 7-4. Computation of Sterneck latitude.



LATITUDE (STERNECK METHOD)
TM 5-442

STATION	PROJECT		LOCATION	
OBSERVER	CIRCLE / GROUP	TEMPERATURE	C_T	C_{BT} / LOCAL DATE
ASSISTANT OBSERVER	INDEX CORR. (*I.C.*)	PRESSURE	C_B	INSTRUMENT / d/2

STAR	N/S	L. SID. TIME t	R.A. α	$\alpha - t$	CIRCLE READING	ZD_o	REFR. $r_m \times C_{BT}$	CORRECTED ZD	DECLINATION δ	LATITUDE ° ′ N	LATITUDE S
		h m s	s	s	° ′ ″	° ′ ″	″	° ′ ″	° ′ ″	N ″	S ″

COMPUTATION OF CONSTANTS

FIRST STAR		η
LAST STAR		
MEAN EPOCH		B'
λ (E −; W +)		
GST		$d\psi$
0^h S.T. (−)		
SIDEREAL INTERVAL		$d\epsilon$
G.C. DATE		

COMPUTER

DATE

REMARKS:

	Σ NORTH
	Σ SOUTH
	DIFFERENCE

1. If $\alpha - t > 6^s$ ADD $\sin^2 t/2 \cdot \sin 2\delta \div \sin 1''$ TO ZD_o
2. If $\phi_N - \phi_S > 2''$ RECOMPUTE NEW I.C.
3. CIRCLE READING + (*I.C.*) = ZD_o

SUMMARY

MEAN ϕ FROM NORTH STARS	
MEAN ϕ FROM SOUTH STARS	
Δ	
LATITUDE OF STATION	

CHECKER

DATE

DA FORM 3619-R, 1 Jul 70

(Paper size 10½ x 8″, image size 9-8/10 x 7″)

Figure 7-4a. DA Form 3619-R.

servation of the north stars and the mean latitude as determined by observation of south stars are computed. The latitude as derived from any individual north (south) star that varies by more than ± 2″5 from the computed mean of the north (south) stars is rejected and a new mean determined. The difference between the mean latitude as determined by the north and south stars is equal to twice the index error. If this double index error exceeds 2 minutes, a new index correction must be determined and the refraction corrections recomputed. The latitude for the group is then determined from the mean of the mean latitude from the north stars and the mean latitude from the south stars.

(3) Values which represent the summation and difference of either the north or south star zenith distances or the north and south star refraction corrections are determined. In either case, the difference should not exceed 10 units, i.e., 10 degrees of zenith distance or 10 seconds of refraction correction.

7–9. Latitude Summary

The observations are summarized on DA Form 1962 (Tabulation of Geodetic Data) (fig. 7–5).

a. Mean Latitude and Residuals. The mean latitude is computed and the residuals determined as shown in figure 7–5.

b. Probable Error. The probable error of the mean latitude is given by:

$$e\phi = \pm 0.6745 \sqrt{\frac{[vv]}{n(n-1)}}$$

Where:

$v =$ the residual
$n =$ the number of groups

The probable error of a single group is given by:

$$e_g = e\phi \sqrt{n}$$

Where:

$n =$ the number of groups

c. Rejections. After computation of the probable error of a group, Chauvenet's Criteria is used to determine the rejection limit, r. The rejection limit is—

$$\pm r = t' e_g$$

Where:

$t' =$ Chauvenet's Criteria
$e_g =$ probable error of a single group

Values of t′ are tabulated in table B–8, appendix B, and are a function of the number of groups in the observation. After any necessary rejections, residuals and probable errors are recomputed.

d. Reduction to Sea Level. This correction is formulated with the assumption that the earth is truly spheroidal and there are no irregularities in the equipotential surfaces. Since the force of gravity is less at the equator than it is at the poles, we find that a level surface (equipotential surface) is farther from sea level at the equator than it is at a point nearer the pole. If several such surfaces were drawn (fig. 7–6) they would be seen to converge toward the pole. They are parallel to each other only at the equator and at the poles. Therefore the normals to each surface, although in the same meridianal plane, will not be parallel. The problem then is to determine the difference in the slope of the sea level surface and the slope of the level surface at the point of observation.

The correction for all spheroids is given by:

$$\Delta \phi = 0''000171\ h \sin 2\phi$$

Where:

$\Delta \phi =$ the correction to the latitude in seconds of arc
$h =$ the elevation of the station in meters
$\phi =$ the astronomic latitude

The correction, tabulated in table B–9, appendix B, numerically reduces the latitude.

e. Polar Variation. The observed latitude must be corrected for polar motion as explained in paragraph 6–28. The correction is given by:

$$\Delta \phi = -(x \cos \lambda + y \sin \lambda)$$

Section II. HORREBOW-TALCOTT Method

7–10. General

a. Basically, latitude is determined from the fact that when two stars on the observer's meridian, one north and one south, have exactly the same zenith distance, the latitude of the observer is equal to one-half the sum of the declinations of the two stars (fig. 7–7).

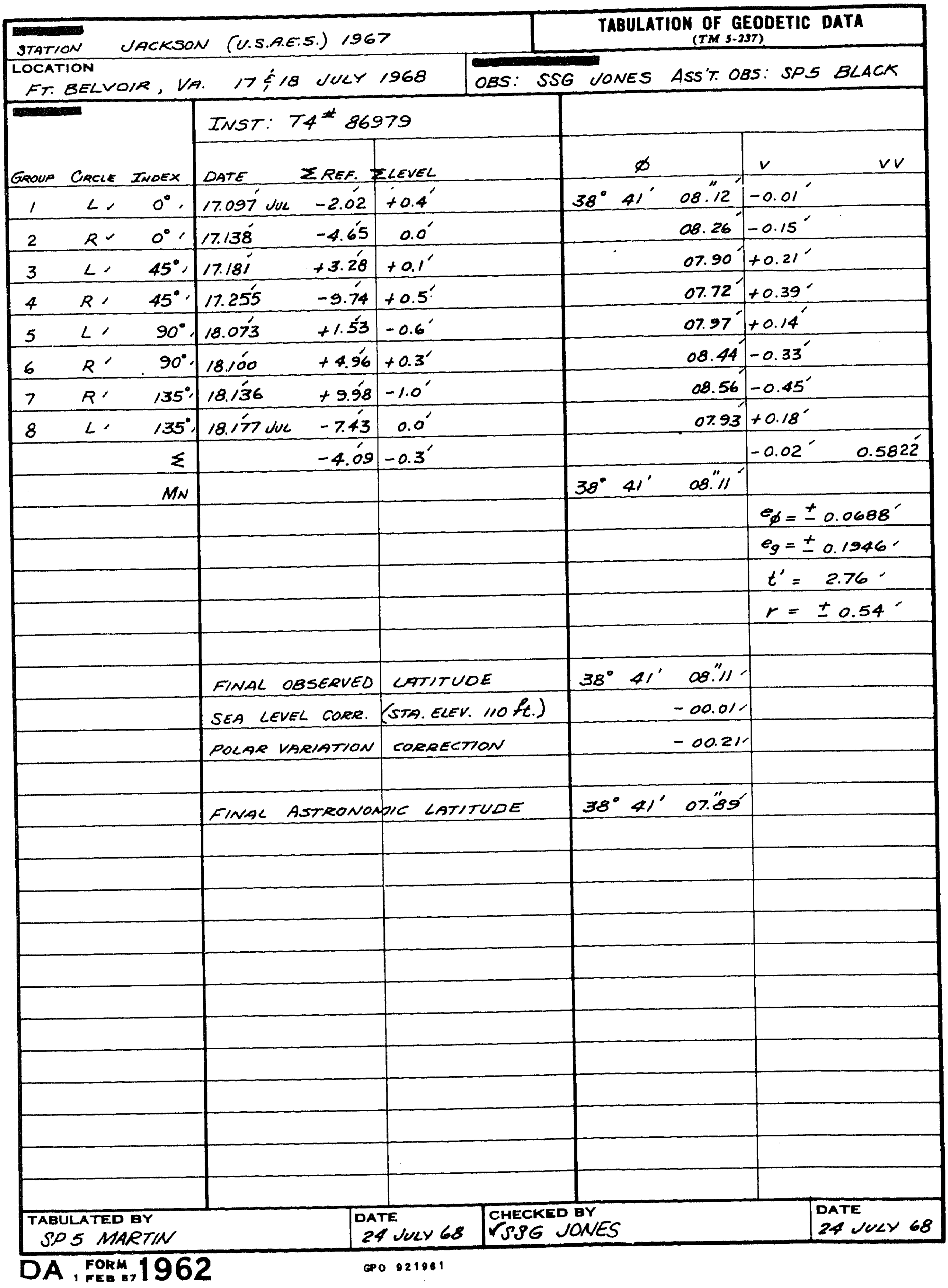
b. In practice, slight differences of meridian zenith distance between paired north and south stars are measured with the eyepiece micrometer and, along with other small corrections, the latitude is computed.

7–11. Specifications

a. First Order.

(1) A valid latitude determination consists of a minimum of 24 acceptable pairs of stars, a pair being one north star and one south star. Since the rejection limit is quite rigid and other criteria must be met, it is recommended that approximately 30 pairs be observed.

(2) The absolute rejection limit for the latitude determined by any pair of stars as compared to the latitude determined by the mean of all pairs shall be ± 3″0; further, the rejection limit shall



[redacted]

STATION JACKSON (U.S.A.E.S.) 1967

TABULATION OF GEODETIC DATA
(TM 5-237)

LOCATION FT. BELVOIR, VA. 17 & 18 JULY 1968

[redacted]

OBS: SSG JONES ASS'T OBS: SP5 BLACK

[redacted]

INST: T4# 86979

GROUP	CIRCLE	INDEX	DATE	Σ REF.	Σ LEVEL	φ	v	vv
1	L	0°	17.097 JUL	-2.02	+0.4	38° 41' 08".12	-0.01	
2	R	0°	17.138	-4.65	0.0	08.26	-0.15	
3	L	45°	17.181	+3.28	+0.1	07.90	+0.21	
4	R	45°	17.255	-9.74	+0.5	07.72	+0.39	
5	L	90°	18.073	+1.53	-0.6	07.97	+0.14	
6	R	90°	18.100	+4.96	+0.3	08.44	-0.33	
7	R	135°	18.136	+9.98	-1.0	08.56	-0.45	
8	L	135°	18.177 JUL	-7.43	0.0	07.93	+0.18	
		Σ		-4.09	-0.3		-0.02	0.5822
		MN				38° 41' 08".11		
							$e_\phi = \pm 0.0688$	
							$e_g = \pm 0.1946$	
							$t' = 2.76$	
							$r = \pm 0.54$	
			FINAL OBSERVED	LATITUDE		38° 41' 08".11		
			SEA LEVEL CORR.	(STA. ELEV. 110 ft.)		- 00.01		
			POLAR VARIATION	CORRECTION		- 00.21		
			FINAL ASTRONOMIC	LATITUDE		38° 41' 07".89		

TABULATED BY	DATE	CHECKED BY	DATE
SP5 MARTIN	24 JULY 68	✓SSG JONES	24 JULY 68

DA FORM 1 FEB 57 **1962**

GPO 921961

Figure 7-5. Sterneck latitude summary.

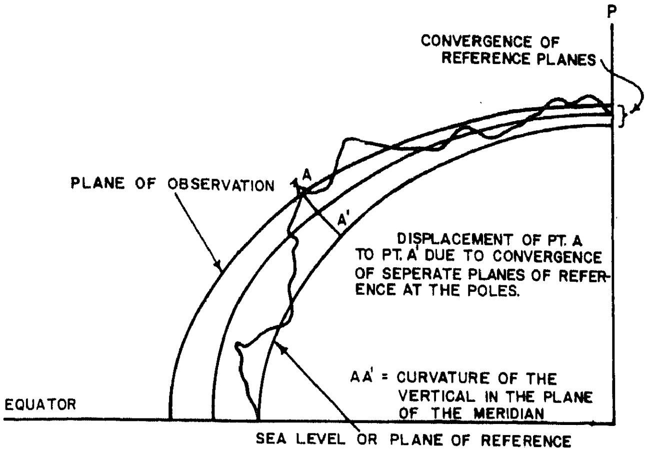

P
CONVERGENCE OF REFERENCE PLANES
PLANE OF OBSERVATION
A
A'
DISPLACEMENT OF PT. A TO PT. A' DUE TO CONVERGENCE OF SEPERATE PLANES OF REFERENCE AT THE POLES.
AA' = CURVATURE OF THE VERTICAL IN THE PLANE OF THE MERIDIAN
EQUATOR
SEA LEVEL OR PLANE OF REFERENCE

Figure 7-6. Reduction to sea level.

be five times the probable error of an observation as determined by the standard formula.

(3) The pairs observed at a station shall be so selected that the algebraic sum of the micrometer differences shall not exceed unity times the number of pairs observed by any one observer during one observation period. Further, the algebraic sum of the micrometer difference for all pairs observed shall not exceed unity times the total number of pairs.

(4) Observations are performed preferably over at least two nights. However, the observations may be completed during one night providing the two observing periods are separated by at least 4 hours. At least eight and preferably 12 or more pairs with a balanced micrometer difference summation are observed during one observing period.

(5) The level vials are so leveled and centered that W-E approaches zero.

(6) The probable error of the latitude shall not exceed ± 0.″10.

(7) Each pair consists of a north star followed by a south star (or a south star followed by a north star). The stars should seldom transit more than 10 minutes apart. The difference in zenith distances shall seldom exceed 20′ and never exceed 25′ of arc. No zenith distance shall exceed 30° and preferably should not exceed 20°.

(8) Double stars which are too close together to be resolved by the telescope shall not be used unless the two elements are sufficiently close that their distance is less than 0.″50 or the coordinates of the combined image are given. Any general catalog star whose probable error in declination, 1950, exceeds ± 0.″50 shall not be used.

(9) Only FK4 stars may be observed more than once at a station in the determination of a latitude.

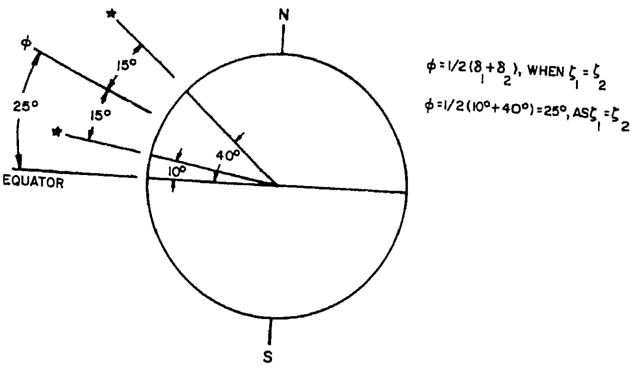

N
S
ϕ
25°
15°
15°
40°
10°
EQUATOR
$\phi = 1/2(\delta_1 + \delta_2)$, WHEN $\zeta_1 = \zeta_2$
$\phi = 1/2(10° + 40°) = 25°$, AS $\zeta_1 = \zeta_2$

Figure 7-7. Horrebow-Talcott latitude precept.

(10) In general the stars should not have a magnitude dimmer than 7.0. Stars of a magnitude that appear too bright for proper bisection shall be reduced by means of a suitable screen placed over the telescope objective. If only one star of a pair requires the use of a screen, a dummy screen must be placed over the objective when observing the other to compensate for the additional weight on the telescope.

b. Modified First Order. The methods, procedures, and specifications for modified first order are the same as first order except as noted.

(1) A determination consists of 10 to 12 acceptable pairs of stars, a pair of stars being one north and one south of the zenith.

(2) The observations may be completed in one observing period.

(3) The probable error of the mean result should not exceed ± 0.″30.

7-12. General Instructions for Observation

a. Before beginning the observation the instrument must be in the meridian within 3 seconds of time.

b. The observer must have prepared a list of stars before observation begins. The stars will be paired by zenith distances, one pair consisting of a north star and a south star of approximately equal zenith distance. These must follow in chronological order. Further instruction on preparing the observing list is given in paragraph 7-13.

c. A radio-chronometer comparison is made by the eye-ear method at the start and at the conclusion of observation. The values as heard on the radio and read on the chronometer are entered to the nearest 0.ˢ1 on the field sheet.

d. The readings of the barometer and dry bulb thermometer are entered on the field sheet at the start and conclusion of observation and at hourly intervals during the observation. The wet bulb temperature should be entered if available.

e. Observations begin in the ocular east or the ocular west position, with the setting circle set to obtain the proper zenith distance. After the telescope is set, the observer places the movable wire to the proper number of full turns as shown by the observing list.

f. The Horrebow levels are locked to the horizontal axis of the telescope and approximately centered with the slow motion tangent screw that acts directly on the level holder.

CAUTION

> After centering the bubbles with the tangent screw neither the level lock nor tangent screw are touched until after the second star is observed.

g. As the star crosses the wire approximating the meridian, the observer precisely bisects the star with the movable wire, in such a manner as to compress the springs in the micrometer box, and calls "tip".

h. The recorder immediately writes down the chronometer time that the star was tipped (to the nearest 0.ˢ1) and the level values as called by the observer (to the nearest 0.1 of a graduation). The two Horrebow levels are read, first the north end and then the south end. In reading the levels, the observer must not breathe on them or hold the light directly on them as the heat tends to move the bubbles and give erroneous readings.

i. The observer calls the number of full turns of the eyepiece micrometer as read in the eyepiece reticle and then the graduations of the micrometer to the nearest 0.1 of a division.

j. The instrument is then rotated about its vertical axis exactly 180°. Since the second star has approximately the same zenith distance as the first, on the opposite side of the meridian, the telescope is already set for the second star.

k. The observer sets the eyepiece micrometer to the proper number of full turns as shown in the observing list and then approximately centers the Horrebow levels *using the vertical slow motion screw* that acts upon the entire telescope. A definite attempt should be made to reset the levels as closely as possible at the same readings that they occupied on the first star of the pair. This reduces the correction and helps the recorder to spot gross errors in reading.

l. As the second star transits, the same procedure is followed as with the first. If either star of a pair is missed the entire pair is void. A pair must consist of one north and one south star in which the Horrebow levels have not been changed in relation to the telescope.

NOTE

> The focus of the eyepiece micrometer must remain unchanged during the entire observation period. The eyepiece, when set properly for latitude observation using this method, has the shaft of the handwheels parallel to the telescope axis.

7-13. Observing List

a. The APFS does not contain sufficient usable pairs of stars for observing a Horrebow-Talcott latitude within a reasonable time-frame; therefore, the SAO or GC is used.

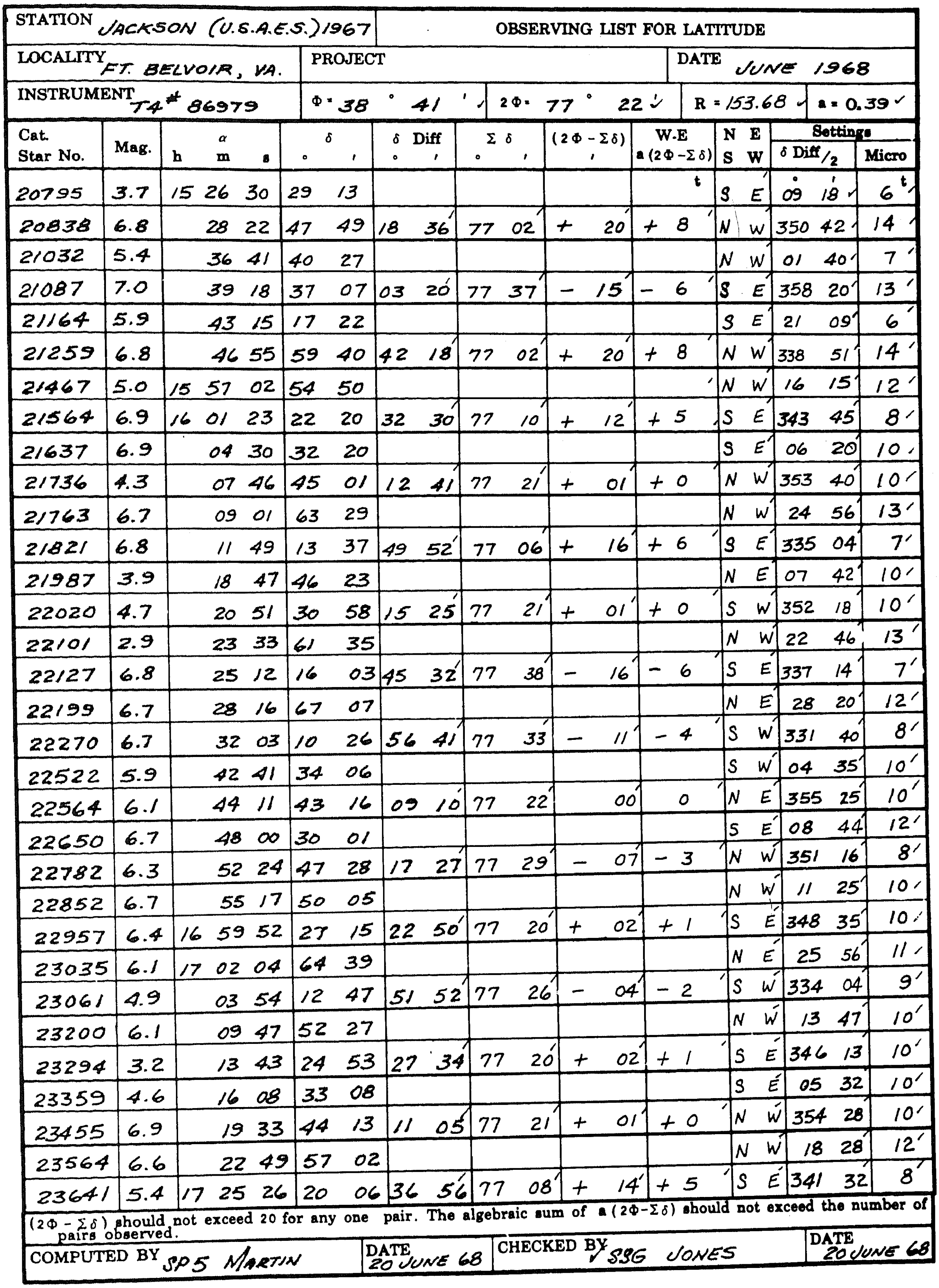
b. The reduction to the time of observation from 1950 is done with sufficient accuracy by multiplying the annual variation of right ascension and declination by the number of years since 1950 and applying the result algebraically to the respective right ascension and declination. Right ascensions are extracted to the nearest second of time and declinations to the nearest minute of arc.

c. The local sidereal time for which the observation is to begin is determined and this time is used as the argument to enter the proper volume of the "GC" to make the observation list. DA Form 3620-R (Observing List for Latitude) (fig. 7-8) is used for recording this list. DA Form 3620-R will be reproduced locally on 8 x 10½-inch paper (image size 6$\frac{9}{10}$″ x 9$\frac{9}{12}$″) (fig. 7-8a). A star whose declination satisfies the zenith distance requirement is found, and a second star whose right ascension satisfies the time requirement and has the proper zenith distance is matched to it. The declination that the second star must have to match the first may be found by subtracting the declination of the first star from twice the assumed latitude, ± 20′ of arc.

d. The first four columns are self-explanatory. The fifth column contains the difference between the declinations of the paired stars and the sixth contains the sum. The seventh column is for differences in minutes of arc between twice the latitude of the observer and the sum of the declinations $(2\phi - \Sigma\delta)$, the result being the difference between the zenith distances of the pair (specifically, zenith distance of south star minus zenith distance of north star). The eighth column is headed "$W{-}E = a(2\phi - \Sigma\delta)$", and expresses the difference in zenith distance in turns of the micrometer where "a" is the number of turns of the eyepiece micrometer per minute of arc

$$a = \frac{60''}{R}$$

where "R" is the value of the eyepiece micrometer in seconds of arc per revolution as determined by



STATION JACKSON (U.S.A.E.S.) 1967	OBSERVING LIST FOR LATITUDE		
LOCALITY FT. BELVOIR, VA.	PROJECT	DATE JUNE 1968	
INSTRUMENT T4 # 86979	Φ = 38 ° 41 ′ ✓	2Φ = 77 ° 22 ✓	R = 153.68 ✓ a = 0.39 ✓

Cat. Star No.	Mag.	α h	m	s	δ °	′	δ Diff °	′	Σ δ °	′	(2Φ − Σδ) ′	W-E a (2Φ − Σδ)	N S	E W	Settings δ Diff/2 °	′	Micro
20795	3.7	15	26	30	29	13						t	S	E	09	18	6 t
20838	6.8		28	22	47	49	18	36	77	02	+ 20	+ 8	N	W	350	42	14
21032	5.4		36	41	40	27							N	W	01	40	7
21087	7.0		39	18	37	07	03	20	77	37	− 15	− 6	S	E	358	20	13
21164	5.9		43	15	17	22							S	E	21	09	6
21259	6.8		46	55	59	40	42	18	77	02	+ 20	+ 8	N	W	338	51	14
21467	5.0	15	57	02	54	50							N	W	16	15	12
21564	6.9	16	01	23	22	20	32	30	77	10	+ 12	+ 5	S	E	343	45	8
21637	6.9		04	30	32	20							S	E	06	20	10
21736	4.3		07	46	45	01	12	41	77	21	+ 01	+ 0	N	W	353	40	10
21763	6.7		09	01	63	29							N	W	24	56	13
21821	6.8		11	49	13	37	49	52	77	06	+ 16	+ 6	S	E	335	04	7
21987	3.9		18	47	46	23							N	E	07	42	10
22020	4.7		20	51	30	58	15	25	77	21	+ 01	+ 0	S	W	352	18	10
22101	2.9		23	33	61	35							N	W	22	46	13
22127	6.8		25	12	16	03	45	32	77	38	− 16	− 6	S	E	337	14	7
22199	6.7		28	16	67	07							N	E	28	20	12
22270	6.7		32	03	10	26	56	41	77	33	− 11	− 4	S	W	331	40	8
22522	5.9		42	41	34	06							S	W	04	35	10
22564	6.1		44	11	43	16	09	10	77	22	00	0	N	E	355	25	10
22650	6.7		48	00	30	01							S	E	08	44	12
22782	6.3		52	24	47	28	17	27	77	29	− 07	− 3	N	W	351	16	8
22852	6.7		55	17	50	05							N	W	11	25	10
22957	6.4	16	59	52	27	15	22	50	77	20	+ 02	+ 1	S	E	348	35	10
23035	6.1	17	02	04	64	39							N	E	25	56	11
23061	4.9		03	54	12	47	51	52	77	26	− 04	− 2	S	W	334	04	9
23200	6.1		09	47	52	27							N	W	13	47	10
23294	3.2		13	43	24	53	27	34	77	20	+ 02	+ 1	S	E	346	13	10
23359	4.6		16	08	33	08							S	E	05	32	10
23455	6.9		19	33	44	13	11	05	77	21	+ 01	+ 0	N	W	354	28	10
23564	6.6		22	49	57	02							N	W	18	28	12
23641	5.4	17	25	26	20	06	36	56	77	08	+ 14	+ 5	S	E	341	32	8

(2Φ − Σδ) should not exceed 20 for any one pair. The algebraic sum of a (2Φ−Σδ) should not exceed the number of pairs observed.

COMPUTED BY SP5 MARTIN	DATE 20 JUNE 68	CHECKED BY ✓ SSG JONES	DATE 20 JUNE 68

DA FORM 3620-R, 1 Jul 70

Figure 7-8. Latitude observing list (Horrebow-Talcott).

STATION	**OBSERVING LIST FOR LATITUDE** **TM 5-442**			
LOCALITY	PROJECT	DATE		
INSTRUMENT	Φ = ° ′	2Φ = ° ′	R = ″	a = 0.

Cat. Star No.	Mag.	α	δ	δ Diff	Σ δ	(2Φ − Σδ)	W-E	N E	Settings	
		h m s	° ′	° ′	° ′	′	a (2Φ − Σδ)	S W	δ Diff/2	Micro
							t		° ′	t

(2Φ − Σδ) should not exceed 20 for any one pair. The algebraic sum of a (2Φ−Σδ) should not exceed the number of pairs observed.

COMPUTED BY	DATE	CHECKED BY	DATE

DA FORM 3620-R, 1 Jul 70

(Paper size 8 x 10½", image size 6-9/10 x 9-9/12")

Figure 7–8a. DA Form 3620–R.

the instrument constants. The value of "R" for most T-4's is approximately 153″ and therefore using 0.′4 as the value for "a" will suffice for the observing list. The ninth column indicates whether the star is north or south and whether the telescope is ocular east or west.

e. The tenth column is the circle setting and is equal to half the difference of the declinations of the pair (column 5). Depending on the position of the eyepiece, either the zenith distance or its explement (360° — ζ) may be necessary. As the stars are on opposite sides of the zenith and both have the same zenith distance only one setting is needed. However, since the ocular position may not be the same as shown in the observing list, both the circle setting and its explement are given. The last column is the micrometer setting in full turns for each star and is derived from the formulas:

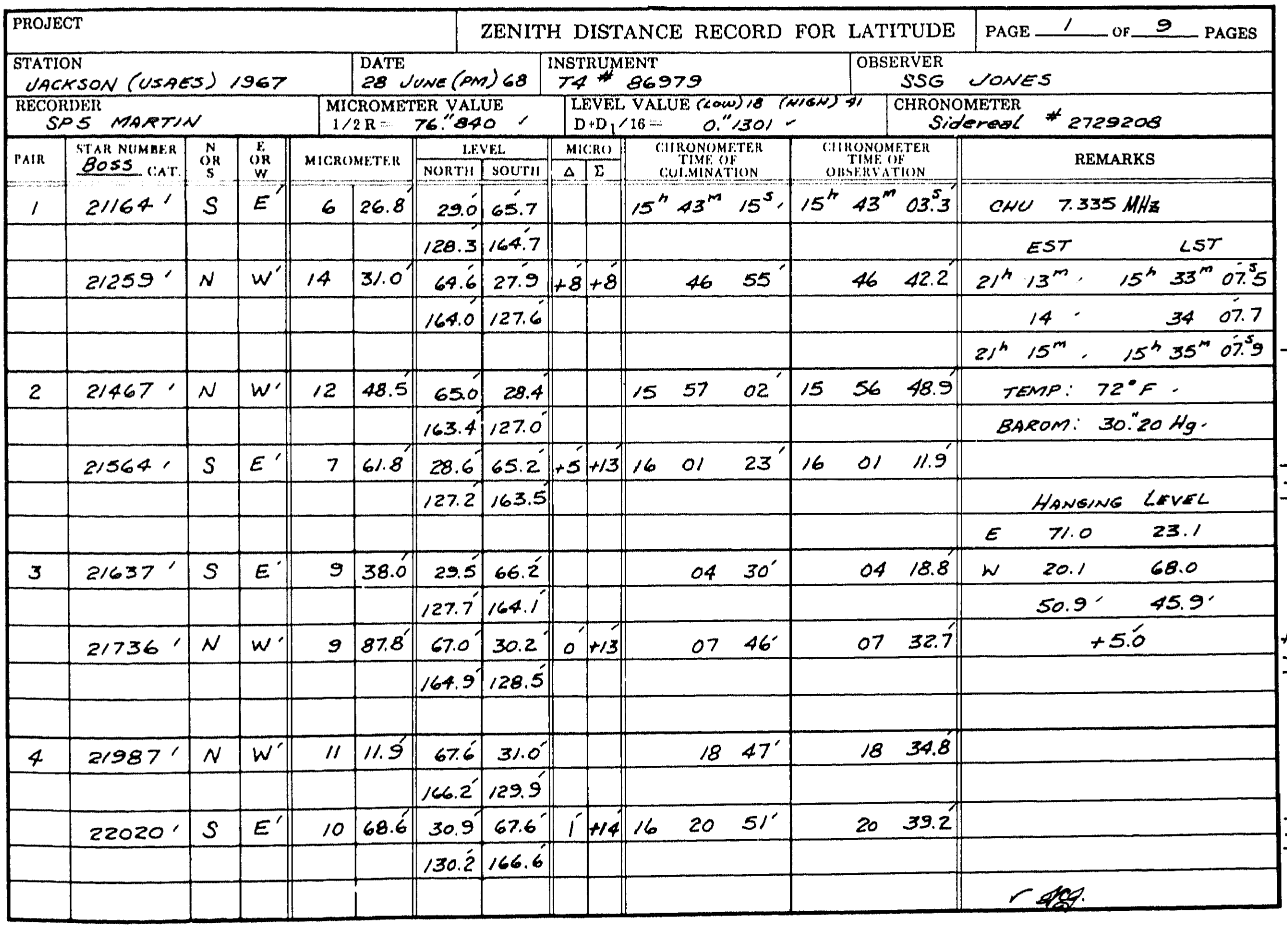
$$\text{for ocular west, } 10 + \frac{W-E}{2}$$

$$\text{or for ocular east, } 10 - \frac{W-E}{2}$$

The formulas are true regardless of the position of the star on the meridian with respect to the zenith. The center of the field is numbered "10" rather than "0" to avoid negative numbers.

7-14. Zenith Distance Record

All information must be entered correctly and fully on the field recording sheet. Figure 7-9 illustrates DA Form 3621-R (Zenith Distance Record for Latitude) which will be used in field recording. When the level values, as read from the instrument, are recorded, the recorder must insure that no gross errors are made by the observer (para. 6-10). The recorder must also check the micrometer readings to insure that the algebraic sum of "W-E", for the pairs observed, does not exceed the number of pairs observed. The closer the sum is to zero the better. The micrometer differences and the accumulative sums are entered in the appropriate column of the record. Because of the possibility of an erroneously assumed latitude, the accumulative sum should be obtained by using the observed differences in the zenith distance rather than the computed differences from the observing list. DA Form 3621-R will be reproduced locally on 8 x 10½-inch paper (image size 9⁶⁄₁₀″ x 7″) (fig. 7-9a).



PROJECT

ZENITH DISTANCE RECORD FOR LATITUDE

PAGE 1 OF 9 PAGES

STATION JACKSON (USAES) 1967

DATE 28 JUNE (PM) 68

INSTRUMENT T4 # 86979

OBSERVER SSG JONES

RECORDER SP5 MARTIN

MICROMETER VALUE 1/2 R = 76.″840

LEVEL VALUE (LOW) 18 (HIGH) 41 D+D₁/16 = 0.″1301

CHRONOMETER Sidereal # 2729208

PAIR	STAR NUMBER BOSS CAT.	N OR S	E OR W	MICROMETER		LEVEL		MICRO		CHRONOMETER TIME OF CULMINATION	CHRONOMETER TIME OF OBSERVATION	REMARKS	
						NORTH	SOUTH	Δ	Σ				
1	21164	S	E	6	26.8	29.0	65.7			15ʰ 43ᵐ 15ˢ	15ʰ 43ᵐ 03.ˢ3	CHU 7.335 MHz	
						128.3	164.7					EST LST	
	21259	N	W	14	31.0	64.6	27.9	+8	+8	46 55	46 42.2	21ʰ 13ᵐ 15ʰ 33ᵐ 07.ˢ5	
						164.0	127.6					14 34 07.7	
												21ʰ 15ᵐ 15ʰ 35ᵐ 07.ˢ9	-1.1
2	21467	N	W	12	48.5	65.0	28.4			15 57 02	15 56 48.9	TEMP: 72°F	
						163.4	127.0					BAROM: 30.″20 Hg	
	21564	S	E	7	61.8	28.6	65.2	+5	+13	16 01 23	16 01 11.9		-0.2
						127.2	163.5					HANGING LEVEL	-1.3
												E 71.0 23.1	
3	21637	S	E	9	38.0	29.5	66.2			04 30	04 18.8	W 20.1 68.0	
						127.7	164.1					50.9 45.9	
	21736	N	W	9	87.8	67.0	30.2	0	+13	07 46	07 32.7	+5.0	+0.7
						164.9	128.5						-0.6
4	21987	N	W	11	11.9	67.6	31.0			18 47	18 34.8		
						166.2	129.9						
	22020	S	E	10	68.6	30.9	67.6	1	+14	16 20 51	20 39.2		+0.1
						130.2	166.6						-0.5

DA FORM 3621-R, 1 Jul 70

Figure 7-9. Zenith distance record (Horrebow-Talcott).

PROJECT

ZENITH DISTANCE RECORD FOR LATITUDE
TM 5-442

PAGE ________ OF ________ PAGES

STATION

DATE

INSTRUMENT

OBSERVER

RECORDER

MICROMETER VALUE
1/2 R =

LEVEL VALUE
$D+D_1/16=$

CHRONOMETER

PAIR	STAR NUMBER ________ CAT.	N OR S	E OR W	MICROMETER		LEVEL		MICRO		CHRONOMETER TIME OF CULMINATION	CHRONOMETER TIME OF OBSERVATION	REMARKS
						NORTH	SOUTH	Δ	Σ			

DA FORM 3621-R, 1 Jul 70

(Paper size 10½ x 8", image size 9-6/10" x 7")

Figure 7–9a. DA Form 3621–R.

7-15. Star Reduction

a. The first step in computation, after a thorough check of the field records, consists of reducing the declinations of the stars observed from the epoch declination, as given in the catalog, to the apparent declination for the epoch of observation.

b. The mean places in the GC must be reduced to the mean places for the year of observation and then to the apparent places for the epoch of observation if Besselian and/or Independent Day numbers are used in the computation. When the yearly computer issue of SAO (available from the US Naval Oceanographic Office) is used, this reduction is not necessary. The SAO mean positions and proper motions are preferred. The illustrations of the latitude observation used in this manual were computed using both GC and SAO mean positions. The difference in the two mean values of the adjusted latitude was less than $0''.01$.

(1) Reduction to the mean place of a star for the year of observation in right ascension and declination is accomplished entirely from the catalog. The expressions for reduction to the mean place for the year are respectively:

$$\alpha_o = \alpha_m + (t_o - 1950)\ \text{An. Var.} + \left(\frac{(t_o - 1950)^2}{200}\right)$$
$$\text{Sec. Var.} + \left(\frac{t_o - 1950}{100}\right)^3 3^d t$$

and

$$\delta_o = \delta_m + (t_o - 1950)\ \text{An. Var.} + \left(\frac{(t_o - 1950)^2}{200}\right)$$
$$\text{Sec. Var.} + \left(\frac{t_o - 1950}{100}\right)^3 3^d t$$

Where:

t_o = the beginning of year nearest observation

Note: If observations are made before 1 July, t_o equals years of observation; if after 1 July, t_o equals year of observation plus one.

α_m = the catalog right ascension

α_o = the mean right ascension for year t_o

δ_m = the catalog declination

δ_o = the mean declination for year t_o

(2) The coefficients of "An. Var.", "Sec. Var." and "3^d t" for both right ascension and declination are arranged in ascending power and must be extracted for each star. All terms of the formula for δ_o will be needed to compute the declination to one hundredth ($0''.01$) of a second; however, the right ascension need be determined only to the nearest second of time so that only the first term is necessary. An illustration of reduction to δ_o for a star is shown below.

Star No	δ_m	An. Var.	Sec. Var.	3^d t
21164	$+17^\circ 25' 12''28$	$-11''329$	$+00.332$	$+0.08$

Year of observation = 1968

$$\delta_o = +17^\circ 25' 12''.28 + (18)(-11''.329) + \left(\frac{18^2}{200}\right)(+0.332) + \left(\frac{18}{100}\right)^3 + (0.08)$$

$$\delta_o = +17^\circ 25' 12''.28 + (18)(-11''.329) + (1.62)(+0.332) + (0.0058)(+0.08)$$

$$\delta_o = +17^\circ 25' 12''28 - 203''.922 + 0''.538 \text{ (last term negligible)}$$

$$\delta_o = +17^\circ 21' 48''.90 = \text{Mean declination for 1968}$$

c. DA Form 2865 (fig. 7-10) has been prepared for use with "Bessel's Day Numbers and Constants" and transformed, for the purpose of machine computation, to the formula shown below. Inasmuch as the reduction to apparent right ascension is unnecessary the formula for α is omitted.

$$\delta = \delta_o + \tau\,\mu' + i\cos\delta_o + X\sin\alpha_o + Y\cos\alpha_o + \Delta\delta + 0.01(t - 1950)\,\Delta\mu'$$

Where:

δ = declination at the instant of observation

δ_o = mean declination for the beginning of the year nearest observation

τ = fractional part of the Besselian Year as extracted from the AE&NA

μ' = proper motion of a star in declination as extracted from the GC

i = obliquity term as extracted from the AE&NA

α_o = mean right ascension for the beginning of the year nearest observation

and:

$X = -(\text{B} + \text{C}\sin\delta_o)$

$Y = \text{A} + \text{D}\sin\delta_o$

A, B, C, and D are Bessel Day Numbers extracted from the AE&NA, $\Delta\delta$ and $\Delta\mu'$ are catalog corrections (see *i* below).

The mean epoch (UT) should be computed for a period not exceeding 4 hours. All sines and cosines should be used to four decimal places and the values of X and Y are to be used to three decimal places. Sines and cosines with time as an argument are included as appendix C.

d. The signs of these functions and all products must be watched closely. The azimuth quadrants of right ascension and declination are respectively:

(1) Right ascension 0^h to 6^h = 1st quadrant
6^h to 12^h = 2nd quadrant
12^h to 18^h = 3rd quadrant
18^h to 24^h = 4th quadrant

(2) Declination
+, upper transit = 1st quadrant
−, upper transit = 4th quadrant

e. Values of "Besselian Day Numbers" and "Independent Day Numbers" are given in the AE&NA for every day of the year with 0^h Ephemeris Time (ET) as the argument.

PROJECT	STATION	LOCATION	DATE	
	JACKSON (USAES) 1967	FT. BELVOIR, VA.	28 JUN(PM)'68	REDUCTION, MEAN TO APPARENT DECLINATION (TM 5-237)

CATALOG STAR NO.	Mag.	MEAN RIGHT ASCENSION α_o			MEAN DECLINATION δ_o			sin δ_o	cos δ_o	μ'	X	sin α_o	Y	cos α_o	$\Delta\delta$ *	$\Delta\mu'$ *	APPARENT DECLINATION δ			PE δ
		h	m	s	°	'	"										°	'	"	
21164		15	43	15	+17	21	48.90	+0.2984	+0.9544	-0.008	+7.586	-0.8272	+2.326	-0.5619	+0.37	+0.46	+17	21	42.78	0.09
21259			46	55	+59	39	58.36	+0.8631	+0.5050	-0.023	+6.205	-0.8361	-9.156	-0.5486	+0.25	+0.26	+59	39	59.02	0.20
21467		15	57	02	+54	50	22.10	+0.8175	+0.5759	+0.015	+6.316	-0.8595	-8.228	-0.5112	+0.30	+0.37	+54	50	21.91	0.07
21564		16	01	23	+22	19	36.02	+0.3799	+0.9250	-0.005	+7.387	-0.8690	+0.669	-0.4948	+0.34	+0.45	+22	19	30.67	0.32
21637			04	30	+32	20	00.71	+0.5348	+0.8449	-0.023	+7.008	-0.8757	-2.481	-0.4829	+0.34	+0.48	+32	19	57.08	0.43
21736			07	46	+45	01	04.14	+0.7073	+0.7069	+0.028	+6.586	-0.8825	-5.988	-0.4704	+0.35	+0.47	+45	01	02.34	0.06
21987			18	47	+46	23	19.24	+0.7240	+0.6898	+0.032	+6.545	-0.9041	-6.327	-0.4274	+0.35	+0.47	+46	23	17.21	0.05
22020			20	51	+30	57	54.74	+0.5145	+0.8575	+0.106	+7.058	-0.9079	-2.068	-0.4193	+0.34	+0.48	+30	57	50.59	0.08
22101			23	33	+61	35	10.39	+0.8795	+0.4758	+0.058	+6.165	-0.9127	-9.489	-0.4085	+0.23	+0.24	+61	35	09.45	0.05
22127			25	12	+16	02	34.41	+0.2764	+0.9611	-0.050	+7.640	-0.9157	+2.773	-0.4019	+0.37	+0.48	+16	02	27.75	0.50
22199			28	16	+67	06	46.72	+0.9213	+0.3889	-0.031	+6.063	-0.9210	-10.339	-0.3897	+0.19	+0.21	+67	06	45.79	0.58
22270			32	03	+10	26	07.39	+0.1811	+0.9835	-0.023	+7.873	-0.9273	+4.711	-0.3744	+0.38	+0.46	+10	25	59.82	0.35
22522			42	41	+34	05	47.78	+0.5606	+0.8281	+0.048	+6.945	-0.9436	-3.005	-0.3310	+0.34	+0.49	+34	05	43.55	0.10
22564			44	11	+43	16	29.96	+0.6855	+0.7281	-0.052	+6.639	-0.9458	-5.545	-0.3248	+0.34	+0.46	+43	16	26.65	0.18
22650			48	00	+30	01	06.46	+0.5003	+0.8659	+0.072	+7.092	-0.9511	-1.779	-0.3090	+0.33	+0.47	+30	01	01.63	0.12
22782			52	24	+47	28	02.25	+0.7369	+0.6760	+0.099	+6.514	-0.9568	-6.590	-0.2907	+0.34	+0.46	+47	27	59.12	0.43
22852			55	17	+50	05	17.36	+0.7670	+0.6416	-0.015	+6.440	-0.9604	-7.202	-0.2786	+0.34	+0.46	+50	05	14.28	0.23
22957		16	59	52	+27	14	33.30	+0.4578	+0.8891	-0.068	+7.196	-0.9658	-0.915	-0.2594	+0.32	+0.45	+27	14	27.90	0.27

29.140

	h m	h m
MEAN EPOCH OBSERVATION	16 42 00	
CORRECTION FOR LONGITUDE	05 08 33	
GREENWICH SIDEREAL TIME	21 50 33	
SIDEREAL TIME 0h G. C. T. 29 Jun '68	18 28 33	
SIDEREAL INTERVAL	03 22 00	
GREENWICH CIVIL DAY	29.140 June	

BESSELIAN AND INDEPENDENT DAY NUMBERS	
A	+8.393
B	-8.316
C	+2.446
D	-20.332
i	+1.061
τ	0.4924

The mean epoch should be for a period not exceeding 4 hours. Use all sines and cosines to 4 decimal places; compute X and Y to 3 decimal places. *Reduction from Boss General Catalogue System to FK System to 2 decimal places.

$$\delta = \delta_o + \mu' + i\cos\delta_o + X\sin\alpha_o + Y\cos\alpha_o + \Delta\delta + .01(t_o - 1950)\Delta\mu'$$

Formulas: $X = -(B + C\sin\delta_o)$

$Y = A + D\sin\delta_o$

MEAN POSITION FROM B.G.C.

PAGE 1 OF 4

COMPUTED BY	DATE	CHECKED BY	DATE
SP5 MARTIN	12 Jul '68	SSG Jones	12 Jul '68

DA FORM 1 OCT 2865

Figuee 7-10. Reduction to apparent declination.

f. Where the period of observation does not exceed 4 hours a mean epoch may be used as the argument in reduction. When there has been a pronounced break in the program or the period has extended over 4 hours, more than one mean epoch should be used.

(1) To determine the mean epoch of a period, the right ascension of the first observed star of that period is summed with the right ascension of the last observed star of that period and the result is divided by two. Since both stars were on the meridian at the time of observation the result is the local sidereal time of the mean observing period. Utilizing the explanation and illustration in paragraph 6–20, the Greenwich Civil Day to the nearest $0^{d}.001$ is determined and used as the argument.

(2) Strictly speaking, this is not entirely correct, since the argument given is "ET" and the argument used is "UT". However, since the relationship:
ET = UT + Δ T (from the table "Δ T" in the AE&NA) exists and since Δ T presently affects the decimal part of a day in the fourth place and we use only the thousandth part of a day we may write without loss of accuracy:

$$ET = UT$$

When the value of Δ T becomes so large that it will affect the third place in the decimal the equation will be:

$$UT = ET - \Delta T$$

g. From the AE&NA, for the year of observation, the values of A, B, C, D, and τ are extracted from the section "Besselian Day Numbers for 19 , for 0^{h} Ephemeris Time". The value "i" is extracted from the section "Independent Day Numbers, 19 for 0^{h} Ephemeris Time".

h. In order to give increased accuracy to the star reduction all values in the AE&NA have been arranged so that they are referred to the nearest half year for the mean place; i.e., when the reduction of stars for the date 24 Mar 68 is undertaken the mean place of the star for 1968 is corrected; however, when the reduction of stars for the date 24 Aug 68 is undertaken, the mean place of the star for 1969 is corrected. We can see that the value of τ is positive from 1 Jan 68 to 1 Jul 68, hence the mean place for 1968 would be used in reduction. A 2-day overlap (1–2 Jul 68) is allowed where the mean place for either 1968 or 1969 may be used; however, the correct tabular value for the selected year must be used.

i. The terms $\Delta\delta$ and 0.01 (t − 1950) $\Delta\mu'$ are used to reduce the position from the GC system to the FK4 system. If the SAO is used no corrections are required. The values of $\Delta\delta$ and $\Delta\mu'$ are tabulated in tables B–10 and B–11, appendix B.

j. An illustration of the Bessel reduction, mean to apparent declination, according to the modified formula is shown below:

Mean epoch	Star No	α_o	μ'
1968 June 29.140	21164	$15^{h}\,43^{m}\,15^{s}$	$-0''.008$

$$\begin{array}{rlrl}
A = & +8.393 & X = & -(-8.316) \\
 & & & +\,(+2.446) \\
 & & & (+0.2984) \\
 & & & = +7.586 \\
B = & -8.316 & Y = & (+8.393) \\
 & & & +\,(-20.332) \\
 & & & (+0.2984) \\
 & & & = +2.326 \\
C = & +2.446 & \delta_o = & +17^\circ\,21'\,48''.90 \\
D = & -20.332 & \tau\mu' = & -0''.0039 \\
i = & +1.061 & i\cos\delta_o = & +1.0126 \\
\tau = & +0.4924 & X\sin\alpha_o = & -6.2751 \\
\sin\delta_o = & +0.2984 & Y\cos\alpha_o = & -1.3070 \\
\cos\delta_o = & +0.9544 & \Delta\delta = & +0''.37 \\
\sin\alpha_o = & -0.8272 & \Delta\mu' = & +0.46 \\
\cos\alpha_o = & -0.5619 & & 0.01\,(t_o - 1950)\,\Delta\mu' \\
 & & & = +0.0828
\end{array}$$

$$\delta = +\,17^\circ\,21'\,42''.78$$

7–16. Computation of Latitude

a. The expression for determination of latitude by the Horrebow-Talcott method with T–4 is:

$$\begin{aligned}\phi = {} & \tfrac{1}{2}(\delta + \delta') + (\tfrac{1}{2}R)(M_w - M_e) \\ & + (d + d_l)/16\,(L_w - L_e) \\ & + \tfrac{1}{2}(r - r') + \tfrac{1}{2}(m + m')\end{aligned}$$

Where:

$(\delta + \delta')$ = the sum of the apparent declinations of the pair of stars at the instant of observation

M_w and M_e = the readings of the eyepiece micrometer, ocular west and ocular east, respectively

d and d_l = level value, in seconds of arc per graduation, of the respective Horrebow-Talcott levels as determined by instrument constants

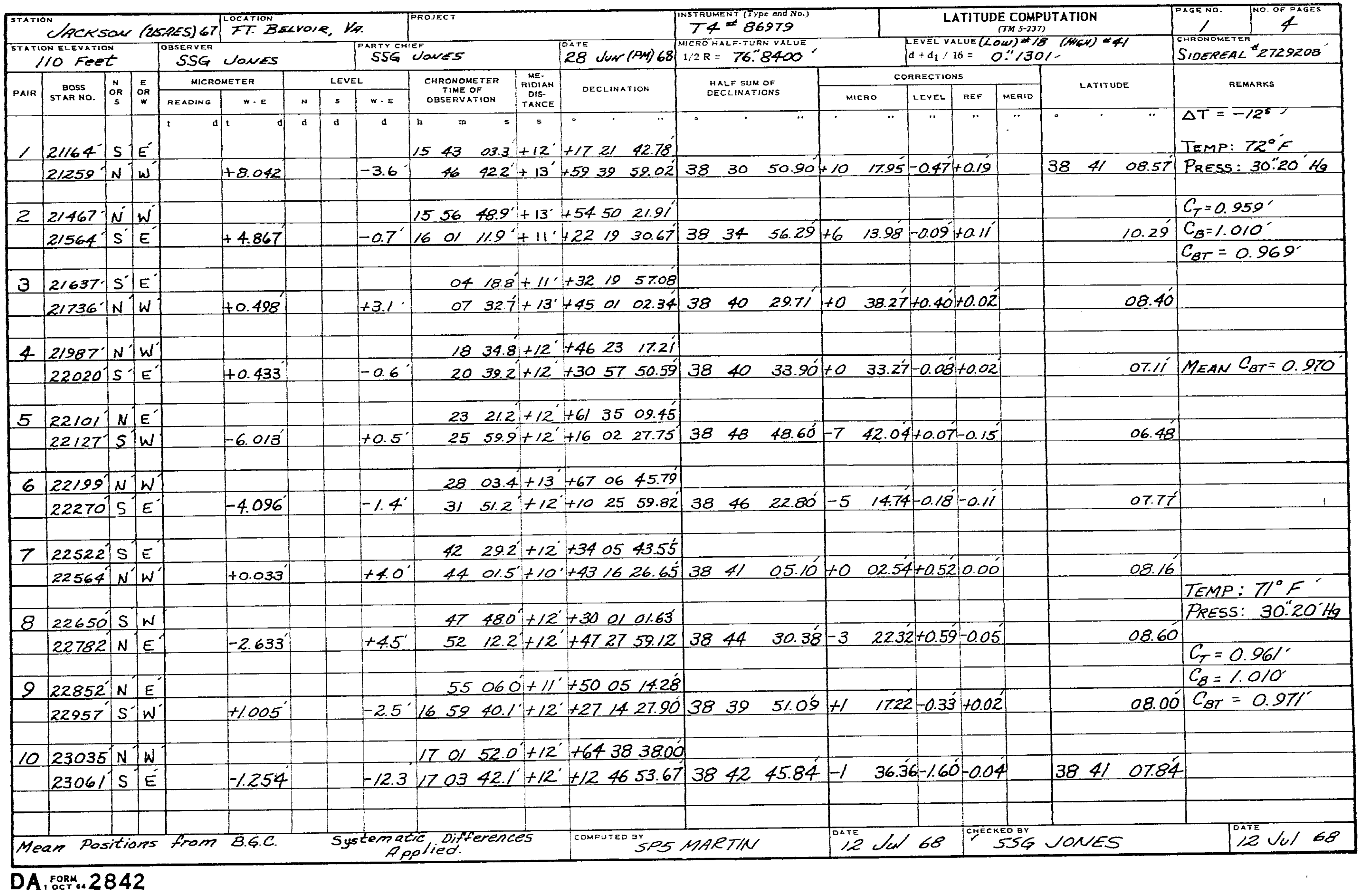
L = the summation of the readings of the north and south ends of both level vials in one ocular position. The subscripts "w" and "e" indicate the ocular position, west and east, respectively

$(r + r')$ = the difference of the refraction correction for each of the stars

$(m + m')$ = the sum of the meridian corrections

The primed values refer to stars observed in ocular east and unprimed values refer to stars observed in ocular west.

b. DA Form 2842 (Latitude Computation) (fig. 7–11) has been prepared for the computation of latitude. It requires little explanation when used in conjunction with the formula.



LATITUDE COMPUTATION
(TM 5-237)

STATION: Jackson (USAES) 67
LOCATION: Ft. Belvoir, Va.
PROJECT:
INSTRUMENT (Type and No.): T4 # 86979
PAGE NO.: 1
NO. OF PAGES: 4
STATION ELEVATION: 110 Feet
OBSERVER: SSG Jones
PARTY CHIEF: SSG Jones
DATE: 28 Jun (PM) 68
MICRO HALF-TURN VALUE: 1/2 R = 76.″8400
LEVEL VALUE (Low) #18 (High) #41: d + d1 / 16 = 0.″1301
CHRONOMETER: Sidereal #2729208

PAIR	BOSS STAR NO.	N OR S	E OR W	MICROMETER READING	MICROMETER W - E	LEVEL N	LEVEL S	LEVEL W - E	CHRONOMETER TIME OF OBSERVATION	MERIDIAN DISTANCE	DECLINATION	HALF SUM OF DECLINATIONS	CORRECTIONS MICRO	CORRECTIONS LEVEL	CORRECTIONS REF	CORRECTIONS MERID	LATITUDE	REMARKS
				t d	t d	d	d	d	h m s	s	° ′ ″	° ′ ″	′ ″	″	″	″	° ′ ″	ΔT = −12ˢ
1	21164	S	E						15 43 03.3	+12	+17 21 42.78							Temp: 72°F
	21259	N	W		+8.042			−3.6	46 42.2	+13	+59 39 59.02	38 30 50.90	+10 17.95	−0.47	+0.19		38 41 08.57	Press: 30.″20 Hg
2	21467	N	W						15 56 48.9	+13	+54 50 21.91							$C_T = 0.959$
	21564	S	E		+4.867			−0.7	16 01 11.9	+11	+22 19 30.67	38 34 56.29	+6 13.98	−0.09	+0.11		10.29	$C_B = 1.010$
																		$C_{BT} = 0.969$
3	21637	S	E						04 18.8	+11	+32 19 57.08							
	21736	N	W		+0.498			+3.1	07 32.7	+13	+45 01 02.34	38 40 29.71	+0 38.27	+0.40	+0.02		08.40	
4	21987	N	W						18 34.8	+12	+46 23 17.21							
	22020	S	E		+0.433			−0.6	20 39.2	+12	+30 57 50.59	38 40 33.90	+0 33.27	−0.08	+0.02		07.11	Mean $C_{BT} = 0.970$
5	22101	N	E						23 21.2	+12	+61 35 09.45							
	22127	S	W		−6.013			+0.5	25 59.9	+12	+16 02 27.75	38 48 48.60	−7 42.04	+0.07	−0.15		06.48	
6	22199	N	W						28 03.4	+13	+67 06 45.79							
	22270	S	E		−4.096			−1.4	31 51.2	+12	+10 25 59.82	38 46 22.80	−5 14.74	−0.18	−0.11		07.77	
7	22522	S	E						42 29.2	+12	+34 05 43.55							
	22564	N	W		+0.033			+4.0	44 01.5	+10	+43 16 26.65	38 41 05.10	+0 02.54	+0.52	0.00		08.16	
																		Temp: 71°F
8	22650	S	W						47 48.0	+12	+30 01 01.63							Press: 30.″20 Hg
	22782	N	E		−2.633			+4.5	52 12.2	+12	+47 27 59.12	38 44 30.38	−3 22.32	+0.59	−0.05		08.60	
																		$C_T = 0.961$
9	22852	N	E						55 06.0	+11	+50 05 14.28							$C_B = 1.010$
	22957	S	W		+1.005			−2.5	16 59 40.1	+12	+27 14 27.90	38 39 51.09	+1 17.22	−0.33	+0.02		08.00	$C_{BT} = 0.971$
10	23035	N	W						17 01 52.0	+12	+64 38 38.00							
	23061	S	E		−1.254			−12.3	17 03 42.1	+12	+12 46 53.67	38 42 45.84	−1 36.36	−1.60	−0.04		38 41 07.84	

Mean Positions from B.G.C. Systematic Differences Applied.
COMPUTED BY: SP5 Martin
DATE: 12 Jul 68
CHECKED BY: SSG Jones
DATE: 12 Jul 68

DA FORM 1 OCT 64 2842

Figure 7-11. Latitude computation.

(1) The heading of the form is properly completed, with the values of ½R and d + $d_l/16$ being taken from the list of instrument constants.

(2) Columns 1, 2, 3, 4, and 10 are entered from the field record. Column 12 is entered from the DA Form 2865 (Reduction Mean to Apparent Declination).

(3) Column 6, headed "Micrometer, W–E", is entered from the field record. Column 5, which is for the micrometer readings, need not be used unless the form is sent from the field uncomputed. The value of W–E is multiplied by ½R and the result (the micrometer correction in seconds of arc) is entered in column 14 with proper algebraic sign.

(4) The level difference, column 9, comes from the expression ($L_w - L_e$). The difference is the level correction expressed in terms of graduations on the level vial. It is multiplied by $(d + d_l)/16$ to give the correction in seconds of arc and is then entered in column 15, "Level", with the proper algebraic sign. Columns 7 and 8 need not be used unless sent from the field uncomputed.

c. Because of the slight difference in zenith distances of the stars the refraction (para. 7–8*b*) correction, ½(r—r′), is small but must still be considered. The refraction correction may be extracted from table B–12, appendix B.

(1) Note that at this point of the latitude computation, column 13 contains the half sum of the declinations. This value is an approximation of the latitude. The zenith distance argument may therefore be obtained by finding the difference between the latitude and the declination of either star in the pair. The value obtained to the nearest 1 degree is normally sufficient for use with the tables. The other argument is obtained by using the value in the "Micro" correction column, converting the seconds of the correction to decimals of a minute.

(2) Inasmuch as this table is computed for an assumed mean atmosphere it must still be corrected for atmospheric pressure and temperature using the formula:

$$REF = \tfrac{1}{2}(r - r')\,(C_T)\,(C_B)$$

The correction coefficients are given in tables B–4 (C_T) and B–5 (C_B), appendix B. An example of the computation of the refraction correction is shown below.

$\phi = 38°41'$ $\delta_s = +17°22'$ $\delta_n = +55°40'$

$ZD_s = 21°19'$ $ZD_n = 20°59'$

$\tfrac{1}{2}R\,(M_w - M_e) = 76''.84\,(+8.042) = 617''.95$

$= 10'.3 = \tfrac{1}{2}\,\Delta ZD$

hence, $\tfrac{1}{2}(r - r') = +0.20$ Temp = 72°F Pres

$= 30''.20$ *hg*

$C_B = 1.010$ $C_T = 0.959$ $C_{BT} = 0.969$

Refraction $= \tfrac{1}{2}(r - r')\,(C_{BT})$

$= (+0.20)\,(0.969) = +0''.19$

(3) If the recorded temperature and pressure vary over a period of observation, a mean of the first and last recordings should be used. The refraction correction always has the same sign as the micrometer correction. The correction, with the proper sign, is entered in the column "REF".

d. In meridian reduction (para. 7–8*e*), the algebraic sign of the correction is the same sign as the star's declination.

7–17. Latitude Adjustment

a. After a latitude has been computed from each star pair, any latitude that varies from the arithmetic mean of all latitudes by greater than ± 3″.0 is rejected, provided that a reliable micrometer value was used in the initial computations. Otherwise a preliminary probable error must be computed at this point and rejections made using table B–8, appendix B. The remaining pairs are entered on the DA Form 2843 (Astronomic Latitude Summary) (fig. 7–12). Data for the first four columns are taken directly from DA Form 2842; micrometer differences are taken to the nearest 0.1 of a turn. A mean is made of the latitudes, and the residuals in the form of ($\Delta\phi$) are entered in column 5. The probable error of an individual observation is computed from the expression:

$$e_p = \pm\, 0.6745 \sqrt{\frac{[\Delta\phi]}{P-2}}$$

where the brackets indicate a sum and "P" is the number of pairs. Rejections are determined using table B–8, appendix B, and the principles are given in paragraph 7–9*c*.

b. If "P" is the number of acceptable latitudes, "c" the amount that an observation varies in seconds of arc from the most probable latitude, "r" the amount by which the preliminary value of one turn of the micrometer must be corrected, and "M" the micrometer difference of each observation, then there will be "p" equations of the form:

$$c - Mr + \Delta\phi = v$$

Inserting the condition that $[v^2]$ must be a minimum, the normal equations to be solved for "c" and "r" are:

$$pc - [M]\,r + [\Delta\phi] = 0$$

and

$$-[M]\,c + [MM]\,r - [M\,\Delta\phi] = 0$$

Where:

[ ] is the standard symbol indicating a sum.

For example:

$30c + 2.0r - 0.03 = 0$

$30c = -2.0r + 0.03$

$c = -0.06667r + 0.00100$

Mean Differences from B.G.C. Applied Page 1 of 2

PROJECT	**ASTRONOMIC LATITUDE SUMMARY** *(TM 5-237)*		
OBSERVER SSG JONES	DATE 28 JUNE (PM) 1968	STATION JACKSON (U.S.A.E.S.) 1967	
CHIEF OF PARTY SSG JONES	INSTRUMENT T4 # 86979	LOCATION FT. BELVOIR, VA.	

STAR NUMBER BOSS GEN. CATALOG		Mic. Diff. M	ϕ 38° 41′	$\Delta\phi$	$\overline{\Delta\phi}^2$	Mr	ADJUSTED ϕ	$\Delta\phi$	$\overline{\Delta\phi}^2$
21164	21259	+8.0	08.57	−0.49		−0.05	08.52	−0.44	
21467	21568	+4.9	10.29	REJECT					
21637	21736	+0.5	08.40	−0.32		0.00	08.40	−0.32	
21987	22020	+0.4	07.11	+0.97		0.00	07.11	+0.97	
22101	22127	−6.0	06.48	REJECT					
22199	22270	−4.1	07.77	+0.31		+0.03	07.80	+0.28	
22522	22564	+0.0	08.16	−0.08		0.00	08.16	−0.08	
22650	22782	−2.6	08.60	−0.52		+0.02	08.62	−0.54	
22852	22957	+1.0	08.00	+0.08		−0.01	07.99	+0.09	
23035	23061	−1.3	07.84	+0.24		+0.01	07.85	+0.23	
23200	23294	+1.2	08.61	−0.53		−0.01	08.60	−0.52	
						0.00			
	27929	+6.7	07.44	+0.64			07.40	+0.68	
27995	28097	+6.9	08.64	−0.56		−0.04	08.60	−0.52	
28197	28284	+1.8	08.18	−0.10		−0.01	08.17	−0.09	
28363	28467	−1.5	07.62	+0.46		+0.01	07.63	+0.45	
28541	28659	−1.7	08.26	−0.18		+0.01	08.27	−0.19	
29012	29136	+3.1	08.24	−0.16		−0.02	08.22	−0.14	
29312	29408	+3.5	08.30	−0.22		−0.02	08.28	−0.20	
+ SUM									
− SUM									
ALGEBRAIC SUM		−2.0		−0.03	5.0321			−0.06	5.0178
MEAN			08.08				08.08		

	UNADJUSTED	ADJUSTED
MICROMETER ONE-HALF TURN VALUE	76.″840	76.″8336
(1) MEAN ϕ 16 PAIRS WITH PLUS MICRO. DIFF.	08.12	08.10
(2) MEAN ϕ 14 PAIRS WITH MINUS MICRO. DIFF.	08.04	08.06
DIFFERENCE (2) − (1)	−0.08	−0.04

NORMAL EQUATIONS

PC − [M]r + [(Δ φ)] = 0	− [M] c + [MM] r − [M(Δ φ)] = 0
$30_c + 2.0_r - 0.03 = 0$	$-2.0_c + 437.86_r + 2.804 = 0$

c = +0.0014	r = −0.0064	$e_p = \pm 0.2856$	$e_\phi = \pm 0.0521$	$e_r = \pm 0.0136$

MEAN OBSERVED LATITUDE	38° 41′ 08.″08
REDUCTION TO SEA LEVEL *(Sta. Elev.* 110 FEET)	−00.01
REDUCTION FOR ~~ECCENTRICITY~~ POLAR VARIATION	−00.23
ASTRONOMIC LATITUDE OF GEODETIC STATION	38° 41′ 07.″84

COMPUTED BY SP5 MARTIN	DATE 13 JULY 1968	CHECKED BY ✓SSG JONES	DATE 13 JULY 1968

DA FORM 1 OCT 64 2843

Figure 7–12. Summary of latitude computations.

$$-2.0c + 437.86r + 2.804 = 0$$
$$-2.0\,(-0.06667r + 0.00100) + 437.86r + 2.804 = 0$$
$$+0.13334r - 0.00200 + 437.86r + 2.804 = 0$$
$$437.99334r + 2.80200 = 0$$
$$437.99334r = -2.80200$$
$$r = -0''.00640$$
$$c = (-0.06667)(-0.00640) + 0.00100$$
$$c = +0''.00143$$
$$\tfrac{1}{2}R \text{ (adjusted)} = 76''.840 + (-0''.00640) = 76''.8336$$

c. Each micrometer value "M" of the accepted observation is now multiplied by "r" and entered in the proper column. Each preliminary latitude is added algebraically to the corresponding "Mr" to produce the corrected latitude and entered in the designated column of DA Form 2843. The mean latitude is entered at the bottom. Once again the rejection limits are applied and if a rejection is made at this time a recomputation is necessary.

d. Reduction to sea level (para. 7-9*d*).

e. Polar variation (para. 7-9*e*).

f. The probable errors (e) are given by the following formulas:

$$e_o = \pm e_p \sqrt{\frac{[MM]}{{}_p[MM] - [M]^2}}$$

and

$$e_r = \pm e_p \sqrt{\frac{p}{{}_p[MM] - [M]^2}}$$

Where:

e_o = probable error in latitude
e_r = probable error in the half turn value of the eyepiece micrometer
p = the number of pairs observed
M = the micrometer difference

Section III. CIRCUM-MERIDIAN METHOD

7-18. General

The circum-meridian method is quite similar to the Sterneck except that a number of zenith distance observations of each star are made at recorded times during the period of a few minutes before and after transit. Each observed zenith distance is then reduced to the meridian. As explained below, the observations are not necessarily made with the instrument in the meridian. This method is especially applicable in high latitudes because of the few hours of darkness during the favorable observing season and the small number of stars suitable for observations.

7-19. Specifications

a. A valid first order latitude determination consists of a minimum of 10 pairs of stars. A pair of stars is one star north and one star south of the zenith. The stars must be listed in the FK4 system (APFS). For lower order determinations the number of pairs are decreased; however, project specifications will usually indicate the number of pairs to be observed .

b. The observations are conducted over at least two, and preferably three, nights. If the mean of one night's observations, of at least two pairs, differs from the mean of all pairs by more than the allowable amount listed below, then additional observations will be made.

Number of pairs on one night	Maximum allowable difference from the mean
2	± 1″.0
3	± 0″.8
4 or more	± 0″.6

c. The difference in zenith distance of the stars in a pair must not exceed 3° and preferably should be less than 1°. Zenith distance of any star must not exceed 30°.

d. The lapse in time between the observation of the two stars in a pair must not exceed 1 hour. Observations do not begin earlier than 5 minutes before transit nor extend more than 5 minutes after transit.

e. An effort is made to obtain an equal number of zenith distance observations of a star both before and after transit.

f. The vertical circle level vial is so leveled and centered that the summation of L-R approaches zero for each pair.

g. The probable error of the arithmetic mean of the observations shall not exceed ± 0″.10 for first order.

7-20. General Instructions for Observation

a. Before beginning the observations the instrument must be in the meridian within ± 3 seconds of time.

b. The observer must prepare an observing list before observations begin. The stars are paired by zenith distance, one pair consisting of a north star and a south star of approximately equal zenith distances. These must follow in chronological order. Further instruction on preparing the list is given in paragraph 7-21.

c. An eye-ear radio chronometer comparison is made at the start, at hourly intervals, and at the conclusion of observations. Values as heard on the radio and read on the chronometer are entered to the nearest 0ˢ.1 on the field record. Two and preferably three consecutive observations of the time should be made, i.e., read the chronometer at the start of a 5-minute period and twice more at identifiable minute pulses (para. 8–6).

d. The eyepiece micrometer should be in the longitude position. The instrument is reversed between stars of a pair, so that both are observed either circle left or circle right.

e. The instrument should be leveled accurately. As some observations are made "out of the meridian" a poorly leveled instrument can cause a large change in the vertical circle level readings during the observation on a star.

f. Barometric pressure and air temperature are read and recorded at the start and completion of observations of each star.

g. To make computations easier the vertical collimation should be adjusted accurately and the vertical circle setting should be as close to 00° 00′ 00″.0 as possible (para. 7–7).

7–21. Observing List

The circum-meridian star observation list (DA Form 3618–R) (fig. 7–13) should be included with the longitude observing list. The starting azimuth of the stars which may be observed should be included, especially when the latitude is greater than 70°. The only requirement for star selection is that the zenith distance shall not exceed 30°.

7–22. Observing Methods

Observations may be made by one of two methods (meridian or azimuth) depending upon the zenith distance of the stars.

a. Meridian method. The instrument should be clamped in the meridian when observing stars whose "A" factors are less the 0.15. The star is bisected, using the vertical slow motion screw of the telescope, at successive points along the horizontal wire. When this method is used the star should also be observed at the exact time of transit. This will assist the computer to determine the azimuth error of the instrument.

(1) The azimuth factor for stars (para. 5–4*b*) may be taken from table B–1, appendix B.

(2) Observations should be made as rapidly as possible. This requires coordination on the part of the observer and assistant observer. An equal number of observations before and after transit should be made. The observer must tell the recorder which observation is made at the time of transit.

(3) When the meridian method has been used there are two additional corrections that must be computed. These corrections are for inclination of the horizontal crosswire and for collimation error. These corrections are explained in paragraphs 7–24*e*(1) and (2).

(4) Zenith distance observations using the meridian method are performed in the following manner:

(*a*) With the instrument in the meridian, telescope at the proper zenith distance, and the vertical circle level closely centered, the observer waits until the star has moved to the "05" or "15", as applicable.

(*b*) The observer gives a 5- to 10-second "standby" order to the recorder, bisects the star by the horizontal wire (using the vertical slow motion screw), and calls "tip" at the instant of bisection.

(*c*) The recorder immediately enters the chronometer time on the field record, DA Form 5–69 (fig. 7–14). The assistant observer reads the vertical circle level vial, left end first, and then reads the vertical circle. Two coincidences of the micrometer which agree within 0″.2 are recorded.

(*d*) The observer again bisects the star using the vertical slow motion screw and the above procedure is repeated.

(*e*) This process continues until an equal number of observations before and after transit have been made, as well as an observation when the star crosses the center wire.

b. Azimuth Method. When the "A" factors of those stars between the zenith and the equator exceed 0.15, the motion of the star in the telescope is so great that very few observations on a star can be made. For this reason the instrument is taken out of the meridian and direct pointings made on the star.

(1) To reduce errors the pointing begins about 5 minutes before transit and continues until about 5 minutes after transit, i.e., within the interval that the star's hour angle is ± 5^m.

(2) The azimuth of a star close to the meridian at hour angle "t" is:

$$Az'' = \frac{t' \times 15}{A}$$

Where:

A = the star's azimuth factor

Therefore the azimuth of a star with an hour angle of 5^m is:

$$Az = 4500''/A = 75'/A$$

After determining the star's azimuth, turn the instrument to the east (west for subpolar stars) at the precomputed azimuth and set the approximate zenith distance of the star on the telescope. This will verify finding the correct star and greatly facilitate finding the star under daylight conditions.

PROJECT

OBSERVING LIST FOR LONGITUDE

ORGANIZATION U.S. Army Map Service

STATION ISUNGUA (AMS) 1961✓

LOCATION Baffin Island, Can

λ

φ 69° 46′ ✓

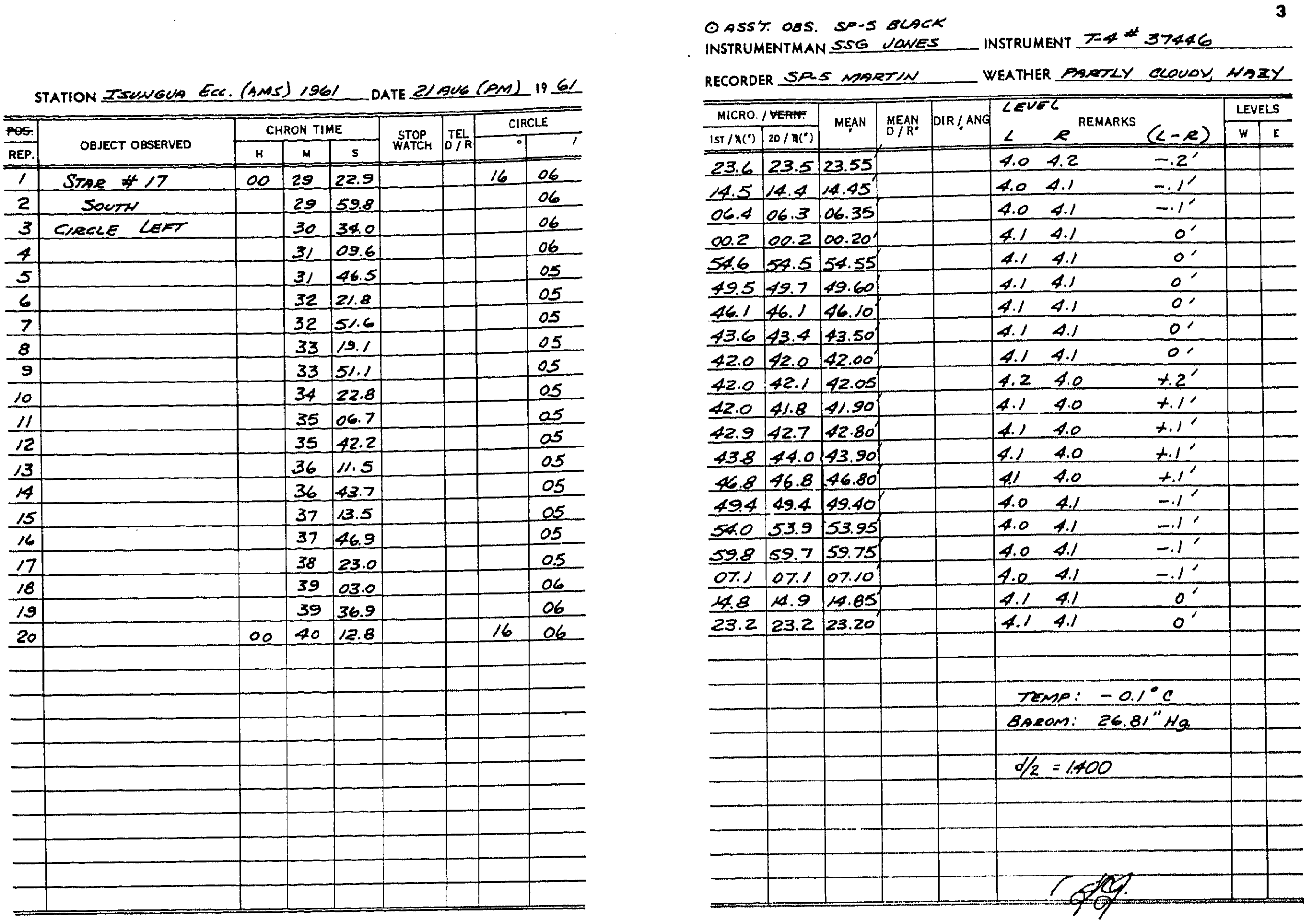
DATE (Local) AUG. 1961✓

STAR No.	α	MAG.	δ	N or S	ζ	360-ζ	AZ.	A
Polaris	$00^h\ 00^m\ 00^s$	LST		N	19° 18′	340° 42′	01° 20′	
2	07 02	2.4	+58° 56′	S	10 50	349 10	176 19	+0.37
16	30 42	4.2	+62 43	S	07 03	352 57	175 12	+0.26
17	34 44	3.7	+53 41	S	16 05	343 55	177 20	+0.47
21	38 13	2.3	+56 19	S	13 27	346 33	176 57	+0.41
1021	47 36	4.4	+40 52	S	28 54	331 06	178 03	+0.64
32	54 17	2.8	+60 30	S	09 16	350 44	176 06	+0.32
Polaris	$01^h\ 00^m\ 00^s$	LST		N	19 22	340 38	00 42	
Na	02 54	4.5	+86° 03′	N	16 17	343 43		-4.07
48	23 11	2.8	+60 02	S	09 44	350 16	176° 10′	+0.34
1045	34 26	4.2	+41 12	S	28 34	331 26	178 03	+0.64
52	35 32	3.8	+48 26	S	21 20	338 40	177 41	+0.54
57	41 08	4.2	+50 29	S	19 17	340 43	177 33	+0.51
63	51 30	3.4	+63 28	S	06 18	353 42	174 34	+0.23
70	59 58	4.1	+72 14	N	02 28	357 32		-0.11
Polaris	$02^h\ 00^m\ 00^s$	LST		N	19 21	340 39	00° 01′	
73	01 26	2.3	+42° 08′	S	27 38	332 22	178 01	+0.63
93	41 27	4.2	+49 04	S	20 42	339 18	178 44	+0.55
99	47 46	4.0	+55 44	S	14 02	345 58	177 01	+0.43
103	51 24	4.1	+52 36	S	17 10	342 50	177 20	+0.48
Polaris	$03^h\ 00^m\ 00^s$	LST		N	19 22	340 38	359 19	
108	01 53	3.1	+53° 21′	S	16 25	343 35	177 17	+0.46
111	05 33	3.0	+40 48	S	28 58	331 02	178 03	+0.64
112	06 10	4.2	+49 28	S	20 18	339 42	177 36	+0.52
120	21 27	1.9	+49 43	S	20 03	339 57	177 36	+0.53
122	25 49	4.4	+59 48	S	09 58	350 02	177 26	+0.35
131	40 04	3.1	+47 40	S	12 06	347 54	176 10	+0.31

COMPUTED BY SP5 MARTIN	DATE JUL 61	CHECKED BY SSG JONES	DATE AUG 61

DA FORM 3618-R, 1 Jul 70

Figure 7–13. Observing list for longitude and circum-meridian latitude.



STATION Isungua Ecc. (AMS) 1961 DATE 21 Aug (PM) 19 61

~~POS.~~ REP.	OBJECT OBSERVED	CHRON TIME H	M	S	STOP WATCH	TEL D/R	CIRCLE °	′
1	Star # 17	00	29	22.9			16	06
2	South		29	59.8				06
3	Circle Left		30	34.0				06
4			31	09.6				06
5			31	46.5				05
6			32	21.8				05
7			32	51.6				05
8			33	19.1				05
9			33	51.1				05
10			34	22.8				05
11			35	06.7				05
12			35	42.2				05
13			36	11.5				05
14			36	43.7				05
15			37	13.5				05
16			37	46.9				05
17			38	23.0				05
18			39	03.0				06
19			39	36.9				06
20		00	40	12.8			16	06

3

⊙ Ass't. Obs. SP-5 Black
INSTRUMENTMAN SSG Jones INSTRUMENT T-4 # 37446
RECORDER SP-5 Martin WEATHER Partly cloudy, hazy

MICRO. / ~~VERN.~~ 1ST / ʌ(″)	2D / ʌ(″)	MEAN ″	MEAN D/R°	DIR / ANG	Level REMARKS L	R	(L − R)	LEVELS W	E
23.6	23.5	23.55′			4.0	4.2	−.2′		
14.5	14.4	14.45′			4.0	4.1	−.1′		
06.4	06.3	06.35′			4.0	4.1	−.1′		
00.2	00.2	00.20′			4.1	4.1	0′		
54.6	54.5	54.55′			4.1	4.1	0′		
49.5	49.7	49.60′			4.1	4.1	0′		
46.1	46.1	46.10′			4.1	4.1	0′		
43.6	43.4	43.50′			4.1	4.1	0′		
42.0	42.0	42.00′			4.1	4.1	0′		
42.0	42.1	42.05′			4.2	4.0	+.2′		
42.0	41.8	41.90′			4.1	4.0	+.1′		
42.9	42.7	42.80′			4.1	4.0	+.1′		
43.8	44.0	43.90′			4.1	4.0	+.1′		
46.8	46.8	46.80′			4.1	4.0	+.1′		
49.4	49.4	49.40′			4.0	4.1	−.1′		
54.0	53.9	53.95′			4.0	4.1	−.1′		
59.8	59.7	59.75′			4.0	4.1	−.1′		
07.1	07.1	07.10′			4.0	4.1	−.1′		
14.8	14.9	14.85′			4.1	4.1	0′		
23.2	23.2	23.20′			4.1	4.1	0′		

Temp: − 0.1° C
Barom: 26.81″ Hg
d/2 = 1.400

Figure 7–14. Recording for the meridian method.

(3) The star must be, as nearly as possible, bisected at the same place on the horizontal wire, preferably just before the star crosses the vertical center wire. Failure to do this results in an apparent error in the hour angle and introduces an error in the reduction. If both stars of a pair are always bisected with the horizontal wire at the same distance from the center wire, and always before (or after) transit, the azimuth errors at the time of bisection will have opposite signs for the reduction and therefore will compensate for the error in the latitude.

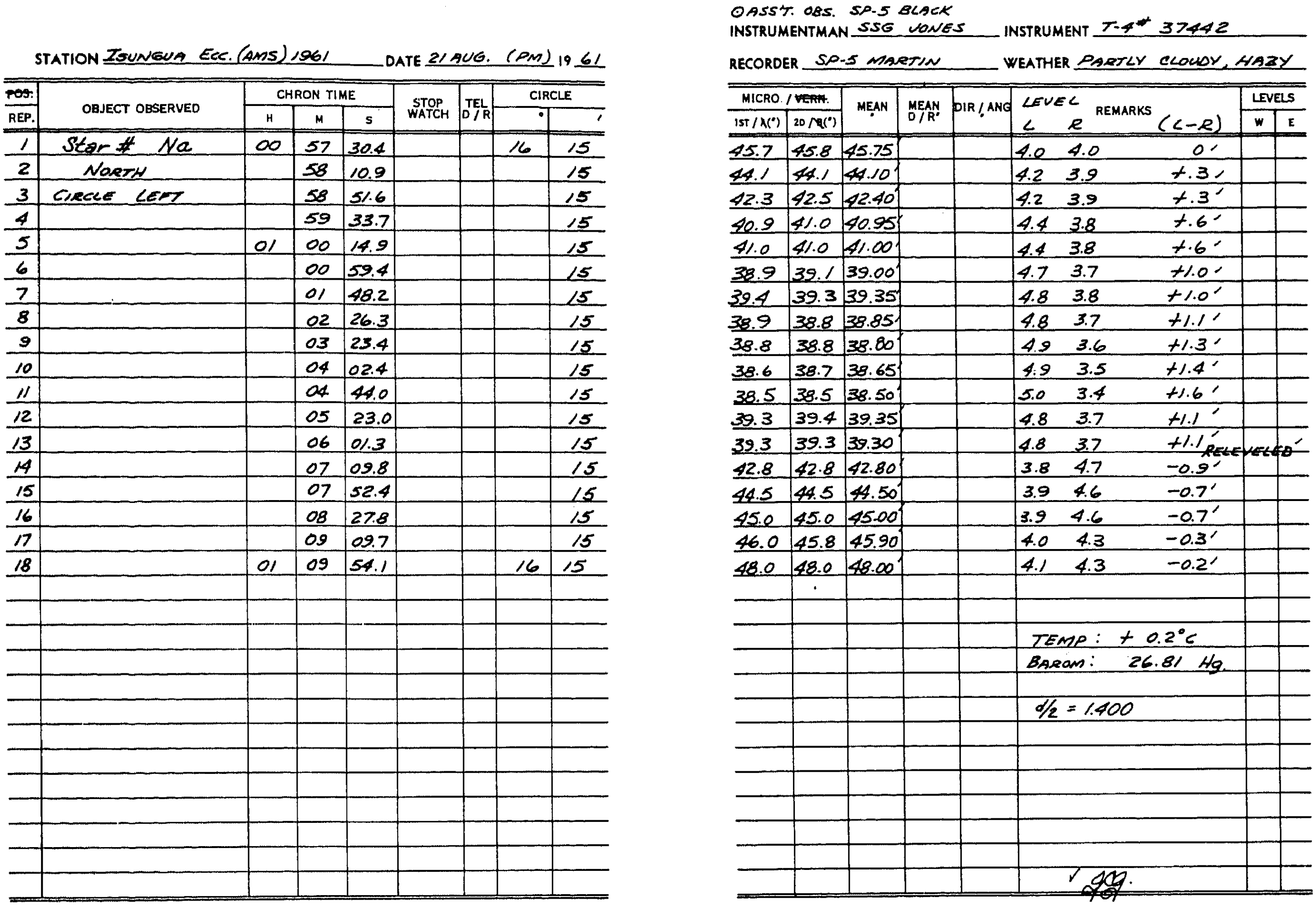
(4) At latitudes above 60°, Polaris may be used as the north star of a pair. Polaris may be observed at any hour angle using the azimuth method and 10 to 12 observations of the zenith distance are observed.

(5) Zenith distance observations using the azimuth method are performed in the following manner:

(*a*) With the instrument set at the proper azimuth, the telescope at the proper zenith distance, and with the vertical circle level closely leveled, the observer waits until the star approaches the center wire and alerts the recorder to "stand-by".

(*b*) Just before the star reaches the center wire the observer bisects the star with the horizontal wire. The bisection may be made in either of two ways. The horizontal wire can be moved into the image of the star by means of the vertical slow motion screw; or the horizontal wire can be moved ahead of the star by means of the vertical slow motion screw, and the instant the star's image is split by the horizontal center wire, the time will be called out to the recorder. The latter method is recommended only for stars whose zenith distance changes relatively rapidly in respect to time.

(*c*) At the instant of bisection, the observer calls "tip" and the recorder reads and immediately enters the chronometer time on the field record (DA Form 5–69) (fig. 7–15). The assistant observer reads the vertical circle level vial, left end first, and then reads the vertical circle. Two coincidences of the micrometer which agree within 0″.2 are recorded.



STATION Isungua Ecc. (AMS) 1961 DATE 21 AUG. (PM) 19 61

~~POS.~~ REP.	OBJECT OBSERVED	CHRON TIME H	CHRON TIME M	CHRON TIME S	STOP WATCH	TEL D/R	CIRCLE °	CIRCLE '
1	Star # Na	00	57	30.4			16	15
2	NORTH		58	10.9				15
3	CIRCLE LEFT		58	51.6				15
4			59	33.7				15
5		01	00	14.9				15
6			00	59.4				15
7			01	48.2				15
8			02	26.3				15
9			03	23.4				15
10			04	02.4				15
11			04	44.0				15
12			05	23.0				15
13			06	01.3				15
14			07	09.8				15
15			07	52.4				15
16			08	27.8				15
17			09	09.7				15
18		01	09	54.1			16	15

⊙ASS'T. OBS. SP-5 BLACK
INSTRUMENTMAN SSG JONES INSTRUMENT T-4# 37442
RECORDER SP-5 MARTIN WEATHER PARTLY CLOUDY, HAZY

MICRO. / ~~VERN.~~ 1ST / λ(")	MICRO. / ~~VERN.~~ 2D / ~~R~~(")	MEAN "	MEAN D/R'	DIR / ANG	LEVEL REMARKS L	LEVEL REMARKS R	LEVEL REMARKS (L-R)	LEVELS W	LEVELS E
45.7	45.8	45.75			4.0	4.0	0'		
44.1	44.1	44.10'			4.2	3.9	+.3'		
42.3	42.5	42.40'			4.2	3.9	+.3'		
40.9	41.0	40.95'			4.4	3.8	+.6'		
41.0	41.0	41.00'			4.4	3.8	+.6'		
38.9	39.1	39.00'			4.7	3.7	+1.0'		
39.4	39.3	39.35'			4.8	3.8	+1.0'		
38.9	38.8	38.85'			4.8	3.7	+1.1'		
38.8	38.8	38.80'			4.9	3.6	+1.3'		
38.6	38.7	38.65'			4.9	3.5	+1.4'		
38.5	38.5	38.50'			5.0	3.4	+1.6'		
39.3	39.4	39.35'			4.8	3.7	+1.1'		
39.3	39.3	39.30'			4.8	3.7	+1.1' RELEVELED'		
42.8	42.8	42.80'			3.8	4.7	-0.9'		
44.5	44.5	44.50'			3.9	4.6	-0.7'		
45.0	45.0	45.00'			3.9	4.6	-0.7'		
46.0	45.8	45.90'			4.0	4.3	-0.3'		
48.0	48.0	48.00'			4.1	4.3	-0.2'		

TEMP: + 0.2°C
BAROM: 26.81 Hg.

d/2 = 1.400

✓ JQG.

Figure 7-15. Recording for the azimuth method.

(*d*) After the assistant observer completes the circle reading, the observer moves the instrument in azimuth to bring the center wire somewhat ahead of the star. The observation procedure is repeated until about 5 minutes after transit of the star.

(*e*) After moving the instrument in azimuth, sufficient time should be allowed for the vertical circle level to settle. The time interval between consecutive bisections should not be less than 30 seconds.

(*f*) If the vertical circle level difference (left minus right) becomes excessive during the observations on a star, the level bubble may be approximately centered during the observation. The centering is done *after* reading the vertical circle for an observation and prior to the next bisection.

7-23. Star Reduction

a. The reduction to apparent right ascension should be correct to ± 0ˢ.1 and the declination correct to ± 0".01.

b. For stars observed at upper (or lower) transit the computation of apparent place is the same as for Sterneck latitude computation (para. 7-8*d*).

c. For Polaris (or other circumpolar stars) at any hour angle the computation of apparent place is the same as for azimuth computations (para. 8-8*b*).

7-24. Computation of Observed Latitude

a. *Preliminary Computation.* Prior to computing the corrected zenith distances, the index correction and preliminary latitude must be determined.

(1) For the preliminary computation select the zenith distance indicated at the transit (meridian method) or the smallest observed zenith distance (azimuth method). For close circumpolar stars at any hour angle select any observation for the preliminary computation.

(2) Correct the selected zenith distances for level error and refraction (*b*(3) and *b*(4) below).

(3) The observed zenith distance of the close circumpolar stars must be further corrected for

the first two terms of the meridian reduction formula (*c*(1) below).

(4) Determine the preliminary latitude from:

$$\phi_n = \delta_n - \zeta_n$$
$$\phi_s = \delta_s + \zeta_s$$
$$\phi = \tfrac{1}{2}\ (\phi_n + \phi_s)$$

And the index correction from:

$$C = \tfrac{1}{2}\ (\phi_n - \phi_s)$$

b. Computation of Corrected Time and Zenith Distance.

(1) The data for each star is abstracted from the field records and entered on DA Form 1962 (fig. 7–16).

(2) The observed chronometer times are corrected for the chronometer correction prior to being entered on the computation form. See paragraph 6–18 for computation of the chronometer correction.

(3) The observed zenith distance from the field record is entered on the form. The level difference (L–R) in the field record is checked and then multiplied by d/2 and this correction entered on the computation form (fig. 7–16).

(4) The refraction correction is computed for each zenith distance and entered on the computing form. If the preliminary computation indicates a small collimation error, the observed zenith distance, corrected for the circle advancement, may be used to determine mean refraction. If the vertical collimation error exceeds 2′ the collimation correction must be applied to the zenith distance prior to determining mean refraction (para. 7–8*b*).

(5) A summation of observed zenith distance, level correction, and refraction correction will give the corrected zenith distance.

c. Computation of Latitude, Circumpolar Stars at Any Hour Angle.

(1) The formula for computation of latitude using the observed zenith distance of close circumpolar stars at any hour angle is:

$$\begin{aligned}\phi = h &- \left[p \cos t + \frac{p^2}{2} \sin^2 t \cot \zeta \sin 1''\right] \\ &- \left[\frac{p^3}{3} \cos t \sin^2 t \sin^2 1''\right] \\ &+ \left[\frac{p^4}{8} \sin^4 t \cot^3 \zeta \sin^3 1''\right] \\ &- \left[\frac{p^4}{24} (4\text{–}9 \sin^2 t) \cot \zeta \sin^3 1'' \sin^2 t\right]\end{aligned}$$

Where:

$h = 90° - \zeta$ (always considered positive)
$p = 90° - \delta$
$t = \text{LST} - \alpha$
ζ = corrected zenith distance

The last term may be neglected for latitudes less than 80°.

(2) The computation may be performed on DA Form 2839 (Latitude from Zenith Distance of Polaris). The index correction should not be included in this computation as the preliminary value is not precise. Combination of the computed latitude with that of a south star will correct for the index correction (fig. 7–17).

d. Computation of Latitude (Azimuth Method).

(1) The formula for the reduction of the observed circum-meridian zenith distances of a star to the meridian is:

$\zeta_1 = \zeta - \text{Am} + \text{Bn}$, for upper transit, and
$\zeta_1 = \zeta + \text{Am} + \text{Bn}$ for subpolar stars.

Derivated from the formula:

$$\zeta_1 = \zeta - \frac{\cos\phi \cos\delta}{\sin\zeta_1} \cdot \frac{2 \sin^2 (\tfrac{1}{2}\tau)}{\sin 1''} + \frac{(\cos\phi \cos\delta)^2}{\sin\zeta_1} \cdot \frac{2 \cot\zeta_1 \sin^4 (\tfrac{1}{2}\tau)}{\sin 1''}$$

Then letting: $m = \dfrac{2 \sin^2 (\tfrac{1}{2}\tau)}{\sin 1''}$, $n = \dfrac{2 \sin^4 (\tfrac{1}{2}\tau)}{\sin 1''}$

$$A = \frac{\cos\phi \cos\delta}{\sin\zeta_1} \quad F = A^2 \cot\zeta_1$$

Where:

ζ = observed zenith distance corrected for refraction and for index error of the vertical circle (collimation and zenith point error)
ζ_1 = zenith distance of star on the meridian
ϕ = astronomic latitude of station
τ = hour angle of star at the instant of observation
δ = declination of the star at transit

Southern latitudes and declinations are negative, the cosine being positive and the tangent, cotangent, and sine being negative.

(*a*) Values of "m" and "n" are functions of the hour angle "τ" and are tabulated in tables B–7 and B–13, appendix B.

(*b*) A and B are constants for all observations on one star. For computing A and B the closely approximated values of ϕ and ζ_1 are required. If the values used in the computation vary more than 5″ from the true value a recomputation of the meridian reduction should be performed.

(*c*) In the above equation the third term was not included and is not normally required. The term is:

$$+ \frac{4}{3} \frac{(1 + 3 \cot^2 \zeta_1)}{\sin 1''} A^3 \sin^6 (\tfrac{1}{2}\tau)$$

At higher latitudes and small zenith distances a computation using the greatest observed hour angle should be made to determine if it should be considered.

(2) If the observations have been distributed symmetrically with respect to time, before and after transit, the final meridian zenith distance is

PROJECT	**TABULATION OF GEODETIC DATA** (TM 5-237)
[redacted] STATION ISUNGUA ECC. (AMS) 1961	ORGANIZATION USAMS, OBS: SSG JONES
[redacted] STAR #17 (SOUTH)	G.C.D. = 22.251 AUG 1961 ✓
	BAROM: 26.81" Hg ✓
	TEMP: -0.1°C ✓

δ	53° 40′ 59″.21 ✓	Cos ϕ	0.345 5917 ✓	ΔT =	$+01^s.9$ ✓
α	00^h 34^m $50^s.99$ ✓	Cos δ	0.592 2507 ✓	$C = C_B C_T$ =	0.928 ✓
ζ_1	16° 05′ 56″.5 ✓	Sin ζ_1	0.277 2984 ✓		
ϕ	69° 46′ 55″.5 ✓	Cot ζ	3.464 8020 ✓		

I	II	III	IV	V	VI
Pos.	Corr. Loc. Sid. T.	Obs. Z.D.	Level	Refrac.	Corr. Obs. Z.D.
	h m s	° ′ ″	″	″	° ′ ″
1	00 29 24.8	16 06 23.55	-.28	+15.53	16 06 38.80
2	30 01.7	14.45	-.14	+15.52	29.83
3	30 35.9	06.35	-.14	+15.52	21.73
4	31 11.5	00.20	00	+15.52	15.72
5	31 48.4	16 05 54.55	00	+15.52	10.07
6	32 23.7	49.60	00	+15.52	05.12
7	32 53.5	46.10	00	+15.52	01.62
8	33 21.0	43.50	00	+15.51	16 05 59.01
9	33 53.0	42.00	00	+15.51	57.51
10	34 24.7	42.05	+.28	+15.51	57.84
11	35 08.6	41.90	+.14	+15.51	57.55
12	35 44.1	42.80	+.14	+15.51	58.45
13	36 13.4	43.90	+.14	+15.51	59.55
14	36 45.6	46.80	+.14	+15.52	16 06 02.46
15	37 15.4	49.40	-.14	+15.52	04.78
16	37 48.8	53.95	-.14	+15.52	09.33
17	38 24.9	59.75	-.14	+15.52	15.13
18	39 04.9	16 06 07.10	-.14	+15.52	22.48
19	39 38.8	14.85	00	+15.52	30.37
20	00 40 14.7	23.20	00	+15.53	38.73

TABULATED BY SP-5 MARTIN	DATE JAN 62	CHECKED BY ✓ SSG JONES	DATE JULY 62

DA FORM 1 FEB 57 1962

Figure 7-16. Computation of corrected time and zenith distance.

LATITUDE FROM ZENITH DISTANCE OF POLARIS

(TM 5-237)

PROJECT			
OBSERVER SSG JONES	UNIVERSAL DATE 12.182 JULY 63 ✓	STATION NORTH (AMS) 1963	
ASST. OBSERVER SP 5 BLACK	RECORDER SP 5 MARTIN	TEMP. 36 °F	BARO. 29.80" Hg ✓
INST. T4# 37446	LEVEL VALUE d/2 = 0."977 ✓	REFRACTION FACTOR 1.0239 ✓	POSITION NO. 1

	h m s		° ' "
CHRON. TIME	17 32 17.9 ✓		28 22 16.95 ✓
CHRON. CORR.	0.0 ✓	LEVEL CORR.	+ 00.98 ✓
LOCAL SID. TIME	17 32 17.9 ✓	REFRACTION CORR	+ 32.01 ✓
R.A.	− 01 57 59.1 ✓	COLLIMATION	+ 11.70 ✓
HOUR ANGLE (t)	15 34 18.8 ✓	ζ	28 23 01.64 ✓
t	233° 34' 42."0 ✓		
			90° 00' 00 00"
LOG p	3.516 4957 ✓	δ	− 89 05 15.30 ✓
LOG COS t	9.773 5840 −10 ✓	p	° 54' 44.70" ✓
LOG I	3.290 0797	p	3284.70" ✓
LOG 0.5	9.698 9700 - 10	LOG 1/3	9.522 88 - 10
2 LOG p	7.032 9914 ✓	3 LOG p	10.549 49 ✓
2 LOG SIN t	9.811 2348 −10 ✓	LOG COS t	9.773 58 −10 ✓
LOG COT ζ	0.267 3390 ✓	2 LOG SIN t	9.811 23 −10 ✓
LOG SIN 1"	4.685 5749 - 10	2 LOG SIN 1"	9.371 15 - 20
LOG II	1.496 1101 ✓	LOG III	9.028 33 −10 ✓
I	+ 1950.20" ✓	LOG 1/8	9.096 91 - 10
II	+ 31.34" ✓	4 LOG p	14.065 98 ✓
III	+ 00.11" ✓	4 LOG SIN t	9.622 47 ✓
IV	+ 00.00" ✓	3 LOG COT ζ	0.802 02 ✓
SUM	+ 1981.65" ✓	3 LOG SIN 1"	4.056 72 - 20
SUM	° 33' 01.65" ✓	LOG IV	7.644 10 −10 ✓
h (90° - ζ)	61 36 58.36 ✓		
ϕ_A	62 10 00.01 ✓		

$$\phi_A = h - I + II - III + IV$$

SIGNS: I and III are PLUS in the first and fourth quadrants.
II and IV are always PLUS.

COMPUTED BY SP 5 MARTIN	DATE JULY 1963	CHECKED BY ✓ SSG JONES	DATE JULY 1963

DA FORM 1 OCT 64 2839

Figure 7-17. Computation of latitude, circumpolar star at any hour angle.

the mean of the reduced zenith distances. This symmetrical distribution is seldom accomplished. Additionally, it is true only if the observer has observed the star at the same point on the horizontal wire and the corrected chronometer time is the exact local sidereal time of observation.

(*a*) When observations have not been symmetrical with respect to time the mean meridian zenith distance is determined from:

$$n(ZD) + [t]\,a - [\zeta_1] = 0 \quad \text{and}$$
$$n'(ZD) + [t']\,a - [\zeta_1] = 0$$

Where:

n = number of observations before transit
ZD = final adjusted meridian zenith distance
$[t]$ = algebraic sum of hour angles (in seconds of time) before transit
a = correction to the zenith distance per second of hour angle (five decimal places)
$[\zeta_1]$ = sum of the zenith distances (seconds only) before transit

The primed terms in the second equation correspond to the same quantities after transit.

(*b*) The equations are solved simultaneously for "ZD" and "a". Then by multiplying "a" times the individual "t's" the adjusted zenith distances are determined (fig. 7–18).

(3) If the observations have not been distributed with respect to the number of observations on each side of the meridian an additional adjustment is necessary. The two equations are:

$$n(\Delta\zeta_1) - [t]\,a + [v] = 0$$
$$-[t]\,(\Delta\zeta_1) - [tt]\,a - [tv] = 0$$

Where:

n = number of observations
$(\Delta\zeta_1)$ = meridian zenith distance
t = hour angle in seconds of time
a = correction to the zenith distance per second of hour angle
v = individual meridian zenith distance (uncorrected for symmetrical time distribution) minus the mean uncorrected meridian zenith distance

The adjustment is illustrated in figure 7–19.

(4) After the final adjusted zenith distance has been computed the observed latitude is determined from:

$$\phi_n = \delta_n - \zeta_n \quad \text{or}$$
$$\phi_s = \delta_s + \zeta_s$$

Where ϕ, δ, and ζ have their usual notation. The subscripts n and s refer to north and south stars respectively. In southern latitudes the algebraic signs change. If a subpolar star is observed the formula becomes

$$\phi_n = 180^\circ - (\delta + \zeta_1)$$

e. Computation of Latitude (Meridian Method).

(1) The formula for the reduction of the observations to the meridian is:

$$m' = \frac{\sin^2 \frac{1}{2}\tau}{\sin 1''}\sin 2\delta$$

Where:

m' = correction to reduce the observed zenith distance to a meridian zenith distance
τ = the hour angle of the star at observation
δ = the star's declination

Values of $\frac{\sin^2 \frac{1}{2}\tau}{\sin 1''}$ are given in table B–7, appendix B. Using τ as the argument the "m" value from the table must be multiplied by 2.

Then, $\zeta_1 = \zeta - m'$

Where:

ζ_1 = meridian zenith distance
ζ = observed zenith distance
m' = correction to the observed zenith distance

(2) As the horizontal wire is seldom exactly perpendicular to the observer's meridian and observations have been made at various points along the wire, a correction for the inclination of the cire is required. The normal equations for the correction are:

$$n(\Delta\zeta) - [t]\,a + [v] = 0$$
$$-[t]\,(\Delta\zeta) + [tt]\,a - [tv] = 0$$

Where:

n = the number of observations
$\Delta\zeta$ = the correction to the mean meridian zenith distance
t = the hour angle of the star at observation
v = mean meridian zenith distance minus individual meridian zenith distances

See figure 7–20. The adjusted zenith distance then becomes:

$$\zeta = \zeta_1 + \Delta\zeta$$

(3) The two previous computations result in a meridian zenith distance that is actually in the plane of the instrument's collimation axis and this must then be reduced to the local meridian. The formula for the correction is:

$$\Delta\zeta_1 = -Am$$

Where:

$$A = \frac{\cos\phi\cos\delta}{\sin\zeta_1} \text{ and } m = \frac{2\sin^2(\frac{1}{2}\tau)}{\sin 1''}$$

$\Delta\zeta_1$ = the correction to be applied to the reduced mean zenith distance of the star
τ = the meridian error of the instrument expressed as an hour angle (local sidereal times at transit minus right ascension of the star)

For algebraic sign of the meridian correction when the instrument is *clamped* in meridian, see paragraph 7–8*e*(3) as it pertains to Sterneck reduction.

PROJECT						TABULATION OF GEODETIC DATA (TM 5-237)			
[redacted] STATION ISUNGUA ECC. (AMS) 1961						ORGANIZATION U.S.A.M.S.			
[redacted] STAR # 17 G.C.D. = 22.251 Aug.		$A = \frac{\cos \phi \cos \delta}{\sin \zeta_1} = 0.73811$ ✓				$B = A^2 \cot \zeta_1 = 1.88765$ ✓			
Pos.	t	m	n	Am	Bn	ζ_1	at	Adj. ζ_1	v
1						16° 05′			
1	-5^m $26^s.2$	58.03	.0082	-42.84	+ .02	$55''.98$	+ .58	56.56	.00
2	4 49.3	45.65	.0051	-33.69	+ .01	56.15	+ .51	56.66	− .10
3	4 15.1	35.49	.0031	-26.20	+ .01	55.54	+ .45	55.99	+ .57
4	3 39.5	26.28	.0017	-19.40	.00	56.32	+ .39	56.71	− .15
5	3 02.6	18.19	−	-13.43	−	56.64	+ .32	56.96	− .40
6	2 27.3	11.84		- 8.74		56.38	+ .26	56.64	− .08
7	1 57.5	7.53		- 5.56		56.06	+ .21	56.27	+ .29
8	1 30.0	4.42		-3.26		55.75	+ .16	55.91	+ .65
9	0 58.0	1.83		-1.35		56.16	+ .10	56.26	+ .30
10	0 26.3	0.38		-0.28		57.56	+ .05	57.61	− 1.05
11	+0 17.6	0.17		-0.13		57.42	− .03	57.39	− .83
12	0 53.1	1.54		-1.14		57.31	− .09	57.22	− .66
13	1 22.4	3.71		- 2.74		56.81	− .15	56.66	− .10
14	1 54.6	7.16		-5.28		57.18	− .20	56.98	− .42
15	2 24.4	11.37		-8.39		56.39	− .26	56.13	+ .43
16	2 57.8	17.24		-12.73		56.60	− .32	56.28	+ .28
17	3 33.9	24.96	−	-18.42	−	56.71	− .38	56.33	+ .23
18	4 13.9	35.16	.0030	-25.95	+ .01	56.54	− .45	56.09	+ .47
19	4 47.8	45.18	.0050	-33.35	+ .01	57.03	− .51	56.52	+ .04
20	5 23.7	57.14	.0079	-42.18	+ .01	56.56	− .58	55.98	+ .58
						56.55^4		56.55^8	+ .05
$\frac{a}{A} = +.00241$		$10\,ZD - 1711.8\,a$		$-562.54 = 0$					
$\Delta t = + 2^s.2$		$10\,ZD + 1669.2\,a$		$-568.55 = 0$					
		$-3381.0\,a$		$+ 6.01 = 0$					
$e_p = \pm 0''.32$		a		$= -0.001\,777\,6$					
$e_m = \pm 0''.07$									
$r = \pm 1''.06$		$10\,ZD = 568.55$		$-2.967 = 565.583$		$ZD = 56.55^8$			
				Corr.		for error in "t" +		0.002	
TABULATED BY SP-5 MARTIN			DATE JAN 62		CHECKED BY ✓SSG JONES			DATE JAN 62	

DA FORM 1 FEB 57 1962

Figure 7–18. Computation of meridian zenith distances and adjustment for nonsymmetrical time.

PROJECT	**TABULATION OF GEODETIC DATA** (TM 5-237)
[redacted] **STATION** ISUNGUA Ecc. (AMS) 1961	**ORGANIZATION** USAMS
[redacted] **STAR #** 17	G.C.D. = 22.251 AUGUST 1961

OBS.	t	ζ_1	V_1	$[tt]$	$[tv_1]$	at	Adj. ζ_1	V_2
		16° 05′					16° 05′	
1	−326.2	55″98	+0″57			+0.45	56″43	+0″13
2	−289.3	56.15	+0.40			+0.40	56.55	+0.01
3	−255.1	55.54	+1.01			+0.35	55.89	+0.67
4	−219.5	56.32	+0.23			+0.30	56.62	−0.06
5	−182.6	56.64	−0.09			+0.25	56.89	−0.33
6	−147.3	56.38	+0.17			+0.20	56.58	−0.02
7	−117.5	56.06	+0.49			+0.16	56.22	+0.34
8	−90.0	55.75	+0.80			+0.12	55.87	+0.69
9	−58.0	56.16	+0.39	+757 704.62	−1052.171	+0.08	56.24	+0.32
10	−26.3	57.56	−1.01			+0.04	57.60	−1.04
11	+17.6	57.42	−0.87			−0.02	57.40	−0.84
12	+53.1	57.31	−0.76			−0.07	57.24	−0.68
13	+82.4	56.81	−0.26			−0.11	56.70	−0.14
14	+114.6	57.18	−0.63			−0.16	57.02	−0.46
15	+144.4	56.39	+0.16			−0.20	56.19	+0.37
16	+177.8	56.60	−0.05			−0.25	56.35	+0.21
17	+213.9	56.71	−0.16			−0.30	56.41	+0.15
18	+253.9	56.54	+0.01			−0.35	56.19	+0.37
19	+287.8	57.03	−0.48			−0.40	56.63	−0.07
20	+323.7	56.56	−0.01			−0.45	56.11	+0.45
	−42.6	56.55	−0.09			+0.04	56.56	+0.07

$\Delta\zeta_1$	= +.01	$[V_2]$	/n = .00	
	56.56	CHECK	56.56	
	$\Delta\zeta_1$	a	η	
	+20.000	+42.6	−0.090	
		−2.13	+0.0045	
e_p = ± 0″08	+	757 704.62	+1052.1710	
	−	90.738	+ .1917	
	+	757 613.882	+1052.3627	
		a =	−.00137	
		$\Delta\zeta_1$ =	+.007	

TABULATED BY SP5 MARTIN	**DATE** JAN 1962	**CHECKED BY** ✓ SSG JONES	**DATE** JAN 1962

DA FORM 1 FEB 57 **1962**

Figure 7–19. Zenith distance adjustment for nonsymmetrical observations.

PROJECT HYPOTHETICAL	**TABULATION OF GEODETIC DATA** (*TM 5-237*)
LOCATION $\phi = 70°N$ $\delta = +54°59'40''$	**ORGANIZATION**

STATION

t		ZD_0	V_0	$[tt]$	$[t V_0]$	ΔZD	ZD	V
	s							
05^m 00^s	− 300	35."05	− 14.53			− 15.00	20."05	− .02
04 12	− 252	32.60	− 12.08			− 12.60	20.00	+ .03
03 25	− 205	30.28	− 9.76			− 10.25	20.03	.00
02 10	− 130	26.90	− 6.38			− 6.50	20.40	− .37
01 30	− 90	24.30	− 3.78			− 4.50	19.80	+ .23
00 10	− 10	20.09	+ 0.43			− 0.50	19.59	+ .44
00 53	+ 53	17.65	+ 2.87			+ 2.65	20.30	− .27
01 47	+ 107	14.70	+ 5.82			+ 5.35	20.05	− .02
02 51	+ 171	11.41	+ 9.11			+ 8.55	19.96	+ .07
04 04	+ 244	07.92	+ 12.60			+ 12.20	20.12	− .09
05 03	+ 303	04.85	+ 15.67			+ 15.15	20.00	+ .03
	− 109	20.52^3	− .03	+ 415,473	+ 20,724.33		20.02^7	+ .03

ΔZD	a	η	
+ 11	+ 109	− 0.03	
	− 9.90909	+ 0.00237	
	+ 415,473.0000	− 20,724.3300	
	− 1,080.0908	+ 0.2976	
	+ 414,392.9092	− 20,724.0324	
	a =	+ 0.05001059	
	ΔZD =	+ .00237	
		− .49555 (a)	(− 9.909)
	=	− .49318	
	ZD_0	20.523	
	ZD =	20."030	

TABULATED BY SP 5 MARTIN	**DATE** JAN 1962	**CHECKED BY** ✓ SSG JONES	**DATE** JAN 1962

DA FORM 1 FEB 57 **1962**

Figure 7-20. Zenith distance adjustment for nonperpendicular crosswire.

7–25. Computation of the Mean Latitude

After the observed latitudes for a pair of stars are summarized on DA Form 1962 (fig. 7–21), the mean latitude for the pair is computed from:

$$\phi = \tfrac{1}{2} (\phi_n + \phi_s)$$

The observed latitude determination for each star contains the effect of index error but the mean latitude from a north and south pair eliminates the error. The index error for each pair can be determined from:

$$c = \tfrac{1}{2} (\phi_n - \phi_s)$$

If the preliminary values of the latitude and the index error vary by more than ± 5″ from the final values the meridian reductions should be recomputed.

7–26. Latitude Summary

a. The observed latitudes are summarized on DA Form 1962 (fig. 7–22). A mean latitude is determined and the probable error of a single pair computed from:

$$e_p = \pm 0.6745 \sqrt{\frac{[vv]}{n-1}}$$

The rejection limit is determined by Chauvenet's Criteria. The rejection factor (t′) is determined from table B–8, appendix B, for the number of pairs. The rejection limit is the product of (t′) (e_p).

b. The probable error of the mean of all pairs is:

$$e_\phi = \frac{e_p}{\sqrt{n}}$$

c. Reduction to sea level (para. 7–9*d*).

d. Polar variation (para. 7–9*e*).

PROJECT	**TABULATION OF GEODETIC DATA** (TM 5-237)
[redacted] STATION ISUNGUA Ecc. (AMS) 1961	**ORGANIZATION** U.S.A.M.S.

[redacted]

STAR	ZENITH DISTANCE	DECLINATION	LATITUDE	
	(1)	(2)	(1 + 2)	
Na (N) ✓	− 16° 15′ 55.″69 ✓	+ 86° 02′ 49.″52 ✓	69° 46′ 53.″83 ✓	
17 (S) ✓	+ 16 05 56.56 ✓	+ 53 40 59.21 ✓	55.77 ✓	
		$\phi_m = \frac{\phi_N + \phi_S}{2}$ =	69° 46′ 54.″80 ✓	

TABULATED BY	DATE	CHECKED BY	DATE
SP 5 MARTIN	JAN 1962	✓SSG JONES	JAN 1962

DA FORM 1 FEB 57 1962

Figure 7–21. Observed latitude from a pair of stars.

[redacted] SUMMARY OF LATITUDE RESULTS	**TABULATION OF GEODETIC DATA** (TM 5-237)
[redacted] STATION: ISUNGUA Ecc. (AMS) 1961	ORGANIZATION U.S.A.M.S. OBS: SSG JONES

[redacted] PAIR NO.	ϕ	V_1	V_2	[VV]
1	69° 46′ 54.″80 ✓	+ 0.″13 ✓	+ 0.″05 ✓	
2	55.60 ✓	(- 0.67) ✓ R	–	
3	54.70 ✓	+ 0.23 ✓	+ 0.15 ✓	
4	54.87 ✓	+ 0.06 ✓	- 0.02 ✓	
5	55.02 ✓	- 0.09 ✓	- 0.17 ✓	
6	54.76 ✓	+ 0.17 ✓	+ 0.09 ✓	
7	54.67 ✓	+ 0.26 ✓	+ 0.18 ✓	
8	55.13 ✓	- 0.20 ✓	- 0.28 ✓	
9	54.83 ✓	+ 0.10 ✓	+ 0.02 ✓	
Mn or Sum	(54.″93) ✓	- 0.01 ✓		
	54.85 ✓		+ 0.02 ✓	(0.6769) ✓
				0.1736 ✓
$e_p(1)$	$= \pm .6745\sqrt{\frac{0.6769}{8}}$	$= \pm 0.''20$ ✓	Rej. Limit = ± .20	× 2.84 = ± 0.″57 ✓
$e_p(2)$	$= \pm .6745\sqrt{\frac{0.1736}{7}}$	$= \pm 0.''11$ ✓	Rej. Limit = ± .11	× 2.76 = ± 0.″30 ✓
e_ϕ	$= \pm 0.11/\sqrt{8}$	$= \pm 0.''04$ ✓		
MEAN OBSERVED ASTRONOMIC LATITUDE:			69° 46′ 54.″85 ✓	± 0.″04 ✓

TABULATED BY SP 5 MARTIN	DATE JAN 1962	CHECKED BY ✓ SSG JONES	DATE JAN 1962

DA FORM 1 FEB 57 1962

Figure 7–22. Summary of circum-meridian latitude observations.

CHAPTER 8

DETERMINATION OF AZIMUTH

Section I. CLOSE CIRCUMPOLAR STARS

8–1. General

a. An astronomic azimuth is the angle measured in the plane of the horizon clockwise from the observer's meridian to the vertical circle containing the observed object. The azimuth is usually referred to south. If the azimuth from the elevated pole of an observer to a celestial body is known, and the horizontal clockwise angle between the celestial body and a terrestrial object is measured, the azimuth at the observer to the terrestrial object is easily computed. In practice this is done by measuring the angle between the terrestrial object and the celestial body and then computing the azimuth of the celestial body at the instant of observation. Where the astronomic azimuth is used in the Laplace correction, it must be observed at a geodetic station where the astronomic position has been observed.

b. Close circumpolar stars should be used whenever visible. However, between the latitudes of 5° N and 10° S, local conditions may be such that close circumpolar stars are not visible. If this is the case the method of "east - west stars" must be used. This section of the chapter deals with azimuth observations in the midlatitudes. Except where specifically discussed in section II the procedures, methods, and practices outlined in this section are applicable to both methods.

8–2. Specifications

a. First Order.

(1) Two sets of observations consisting of 16 positions each, with a minimum of 12 acceptable positions each, are observed. The sets are separated by no less than 4 hours and preferably are observed on different nights.

(2) Any observation with a residual greater than ± 5ʺ.0 from the mean of the set is rejected.

(3) The probable error of the mean astronomic azimuth must not exceed ±0ʺ.30.

(4) Separate means are computed for each set. If the means of the two sets differ by more than ± 1ʺ.0, a third set of 16 positions is observed.

(5) When more than two sets have been observed, any set within ± 1ʺ.0 of the mean is retained.

b. Second Order.

(1) One set of observations consisting of 16 position, with a minimum of 12 acceptable positions, is observed. If time and conditions permit it is desirable that a second set of at least 12 positions be observed.

(2) Any observation with a residual greater than ± 5ʺ.0 from the mean of the set is rejected.

(3) The probable error of the mean astronomic azimuth must not exceed ± 0ʺ.50.

(4) If two sets are observed, separate means are computed for each set. If the means of the two sets differ by more than 2ʺ.0, a third set of positions is observed.

c. Third Order. For third order astronomic azimuth procedures, methods, and specifications see chapter 8, TM 5–441.

8–3. Methods and Instruments

a. The hour angle method (fig. 8–1) uses the hour angle (t) of the star, the colatitude ($90° - \phi$), and the co-declination or polar distance ($90 - \delta$) to compute the azimuth (A) of the star. The astronomic latitude of the observer is used. The declination is obtained from the star catalog. The angle "t" is the local sidereal time of observation minus the right ascension of the star. Although any star may be used, an error in the angle "t" has the least effect upon the azimuth when the hour angle is close to 6^h or 18^h. In the northern hemisphere the use of Polaris at elongation is recommended, although any star with a declination greater than 85° is suitable. In the southern hemisphere the observer must use a southern circumpolar star.

b. In low and midlatitudes, the observations for first order azimuth should be performed with the Wild T–3 or its equivalent. The Wild T–2 theodolite is not sufficiently accurate to give first order results, but may be used for lower order observations. At latitudes near 50° or above, the Wild T–4 theodolite must be used because its level vial is sufficiently accurate for determining inclination corrections to the horizontal directions. Regardless of the instrument used, the plate, striding, or hanging level vials must be calibrated.

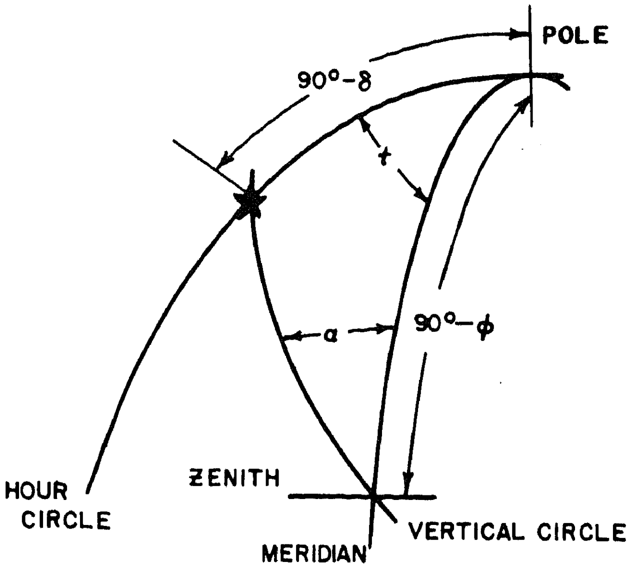


Figure 8-1. Azimuth by hour angle.

8-4. General Instructions for Observations

a. The instrument must be accurately plumbed over the station or a mark of known direction and distance from the station. The instrument must be well adjusted and rest upon a stable support. The standard issue tripod is not ordinarily sufficiently stable, therefore an instrument stand should be used. Lines of sight to the mark and to the star must be unobstructed.

b. The signal should be farther than 1 mile from the instrument and must be properly plumbed, focused, pointed, and illuminated.

c. A radio-chronometer comparison must be obtained just before observation begins and immediately after the conclusion of the observations. The chronometer should be set closely to the local sidereal time. The accuracy of the comparison must be to the nearest $0\overset{s}{.}2$. The recorder should be able to reliably estimate the time of a signal to within 0.1 second.

d. After the observer initially points on the mark he sets and reads the circle. The instrument is pointed on the star and when the star is bisected by the vertical wire the observer calls "tip". The recorder records the time, the level readings (left end first when facing the star), and the circle reading as called by the observer. Level readings are estimated to the nearest 0.1 graduation. The instrument is reversed and again pointed on the star, the star is "tipped", the level and horizontal circle are read, and recorded. With the instrument reversed, a pointing is again made on the mark and the circle is read and recorded. This completes one position. This procedure is repeated until a sufficient number of positions have been obtained.

The increment advancement of the circle must be considered for each position. The initial circle settings for 16 positions with the T-3 and the T-4 theodolites are given in table 8-1.

Table 8-1. Initial circle settings

Number	*Position*	*T-3 Theodolite*	*T-4 Theodolite*
1	D	00° 00′ 10^{units}	00° 00′ 10″
2	R	191 00 25	191 00 25
3	D	22 00 35	22 00 35
4	R	213 00 50	213 00 50
5	D	45 00 10	45 00 10
6	R	236 00 25	236 00 25
7	D	67 00 35	67 00 35
8	R	258 00 50	258 00 50
9	D	90 00 10	90 00 10
10	R	281 00 25	281 00 25
11	D	112 00 35	112 00 35
12	R	303 00 50	303 00 50
13	D	135 00 10	135 00 10
14	R	326 00 25	326 00 25
15	D	157 00 35	157 00 35
16	R	348 00 50	348 00 50

e. If the azimuth mark is greater than 1 degree above or below the horizon of the instrument, the level must also be read for each pointing on the mark, left end first. Two measurements of the zenith distance of the signal are sufficient for the entire set of observations.

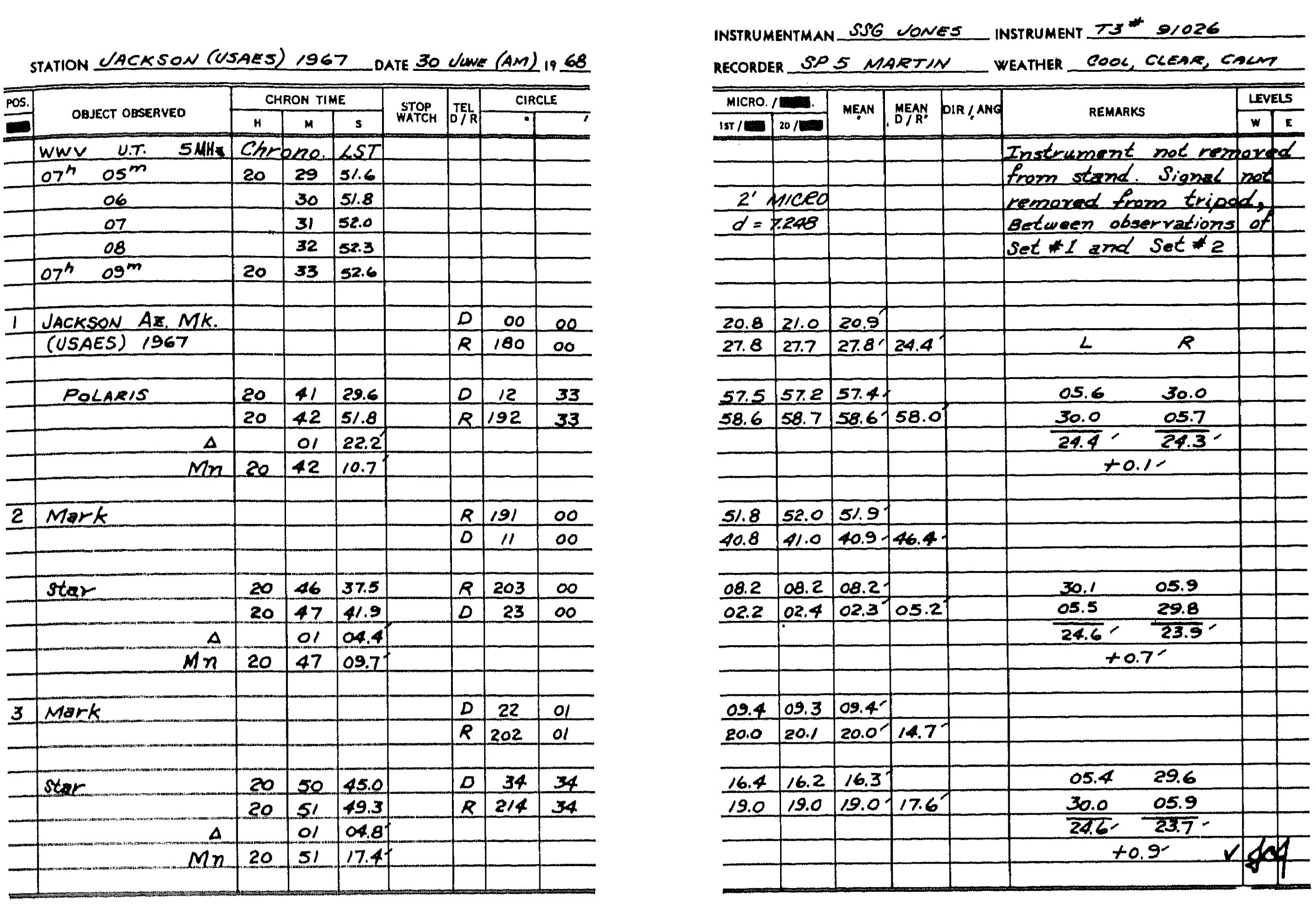
f. With the eye-ear method of determining time the observer must warn the recorder about 5 seconds before the star is bisected in order that the recorder may "count the clock". Just before the star is bisected the observer should say "ready" and, at the instant of bisection, "tip". When the observer warns "ready" the recorder starts counting mentally the seconds and the word "half" for each half second, as; "10, half, 11, half, 12, half, etc". Using this method the recorder can easily determine chronometer time to the nearest $0\overset{s}{.}1$, with an accuracy of ± $0\overset{s}{.}2$.

8-5. Field Records

All records are kept in the field book, DA Form 5-69 (Horizontal Directions or Angles) (fig. 8-2), and must include station name, local date, all radio-chronometer comparisons, position number, times of bisection, horizontal directions, level readings, star and azimuth mark names, zenith distance to mark, and eccentricity. The record must be complete and accurate.

8-6. Time Determination

a. The chronometer should be set closely to the local sidereal time. Radio-chronometer comparisons, the chronometer error, the chronometer rate, and the determination of the corrected time at a given instant are explained in paragraph 6-14.



STATION JACKSON (USAES) 1967 DATE 30 JUNE (AM) 19 68

INSTRUMENTMAN SSG JONES INSTRUMENT T3 # 91026

RECORDER SP 5 MARTIN WEATHER COOL, CLEAR, CALM

POS. / [redacted]	OBJECT OBSERVED	CHRON TIME H	CHRON TIME M	CHRON TIME S	STOP WATCH	TEL D/R	CIRCLE °	CIRCLE ′	MICRO. / [redacted] 1ST / [redacted]	MICRO. 2D / [redacted]	MEAN ″	MEAN D/R″	DIR / ANG ″	REMARKS	LEVELS W	LEVELS E
	WWV U.T. 5MHz	Chrono.		LST										Instrument not removed		
	07^h 05^m	20	29	51.6										from stand. Signal not		
	06		30	51.8					2′ MICRO					removed from tripod,		
	07		31	52.0					d = 7.248					Between observations of		
	08		32	52.3										Set #1 and Set #2		
	07^h 09^m	20	33	52.6												
1	JACKSON Az. Mk.					D	00	00	20.8	21.0	20.9					
	(USAES) 1967					R	180	00	27.8	27.7	27.8	24.4		L R		
	POLARIS	20	41	29.6		D	12	33	57.5	57.2	57.4			05.6 30.0		
		20	42	51.8		R	192	33	58.6	58.7	58.6	58.0		30.0 05.7		
	Δ		01	22.2										24.4 24.3		
	Mn	20	42	10.7										+0.1		
2	Mark					R	191	00	51.8	52.0	51.9					
						D	11	00	40.8	41.0	40.9	46.4				
	Star	20	46	37.5		R	203	00	08.2	08.2	08.2			30.1 05.9		
		20	47	41.9		D	23	00	02.2	02.4	02.3	05.2		05.5 29.8		
	Δ		01	04.4										24.6 23.9		
	Mn	20	47	09.7										+0.7		
3	Mark					D	22	01	09.4	09.3	09.4					
						R	202	01	20.0	20.1	20.0	14.7				
	Star	20	50	45.0		D	34	34	16.4	16.2	16.3			05.4 29.6		
		20	51	49.3		R	214	34	19.0	19.0	19.0	17.6		30.0 05.9		
	Δ		01	04.8										24.6 23.7		
	Mn	20	51	17.4										+0.9 ✓		

Figure 8–2. Azimuth field record.

Corrections for nutation, transmission time, and correction to signal are not required since time for azimuth observations is recorded to the nearest $0^{s}.1$.

b. Although a single reading of the chronometer at a radio signal is generally adequate for an eye-ear comparison, a series of 1-minute signals should be recorded. Recording a series of signals affords the computer a chance to identify a misreading of the chronometer. Five to ten radio minute signals are ideal, but three are sufficient. By reading three to five signals, an adopted mean epoch and corresponding chronometer time may be determined. An eye-ear comparison with the subsequent mean epoch and corresponding chronometer time is shown below.

Radio	Chronometer	Reduction, mean to sidereal	
$0^h\ 05^m$	$11^h\ 37^m\ 26^{s}.4$	+0.33	26.73
06	38 26.5	+0.16	26.76
07	39 26.8	0.00	26.80
08	40 27.0	−0.16	26.84
09	41 27.1	−0.33	26.77
Mn $0^h\ 07^m\ 00^{s}.0$	$11^h\ 39^m\ 26^{s}.78$		26.78

c. If no radio is available, time may be obtained by observation of the altitudes of stars on the prime vertical.

(1) From knowledge of the longitude the local sidereal time may be computed. For determination of time from the altitude of a star the chronometer time of bisection of a star by the horizontal wire of the instrument and the corresponding zenith distance must be measured in four positions on the star. Four positions, direct and reverse, comprise one time set. One time set on a star east of the observer and one time set on a star west of the observer, at about the same altitude, must be measured each time. Before and after each time set the air temperature and barometric pressure must be measured.

(2) The prime vertical of an observer is the great circle passing through the observer's zenith and through his east and west points, hence it has an azimuth of 90° and 270°. The star must be within 30° of the prime vertical and must have an altitude of at least 15°. The instrument must have a good vertical circle and a sensitive level vial. Computation of the time by this method is illustrated and explained in TM 5–237.

8-7. Formula

a. DA Form 1903 (Azimuth by Direction Method) (fig. 8-3) is provided for the computation of azimuth by the hour angle method with natural functions, and DA Form 1904 (Azimuth by Direction Method (Logarithmic)) (fig. 8-4) is provided for the computation with logarithms. Both give the same results.

b. The basic formula for computation of azimuth by the hour angle method is given by:

$$-\tan A = \frac{\sin t}{\cos \phi \tan \delta - \sin \phi \cos t}$$

Where:

A = the clockwise azimuth of the star from the elevated pole
ϕ = the observer's latitude (should be astronomic if possible)
δ = the star's declination
t = the local hour angle of the star, measured westward from 0^{h} to 24^{h}

This formula gives sufficient accuracy for determining the azimuth of any star. There is negligible loss of accuracy when it is used with seven place natural tables although eight place tables are recommended.

c. For logarithmic computation the formula becomes:

$$-\tan A = \cot \delta \sec \phi \sin t \ (1/1 - a)$$

Where:

$$a = \cot \delta \tan \phi \cos t$$

Table B-14, appendix B, has been prepared for the logarithmic values of (1/1 − a) where "a" has been computed from the above formula. The tables are in two sections, plus "a" and minus "a". Attention must be given to these signs. The logarithms for determining "a" are taken to five places and all others to six.

d. Appendix C provides the natural values of the sine and cosine to seven decimal places with the argument expressed in time. Tables of logarithmic functions with a time argument are also available. If these are not used, time must be converted to arc before extracting the functions of "t". The angle "t" is equal to local sidereal time minus right ascension. To determine the sign of the trigonometric function of "t":

Where:

t = 0^{h} to 6^{h} 1st azimuth quadrant
6^{h} to 12^{h} 2nd azimuth quadrant
12^{h} to 18^{h} 3rd azimuth quadrant
18^{h} to 24^{h} 4th azimuth quadrant

e. Positive declinations and northern latitudes are in the 1st quadrant whereas negative declinations and southern latitudes are in the 4th quadrant.

8-8. Computation of Azimuth, Direction Method

a. Before entries are made on the DA Form, a radio-chronometer comparison is computed to find the chronometer corrections and rates. The mean chronometer time of observation for each position is entered on the form and the value of Δ T (considering rate) is then determined and entered. The algebraic sum of chronometer time + ΔT gives the correct local sidereal time of observation (para 6-18).

b. Right ascension and declination of the star observed are determined as follows:

(1) Since the star used for azimuth determination is not normally on the meridian, as is the case with longitude observation, a somewhat different method must be used to extract the apparent position from the APFS.

(2) It is necessary to first determine the mean epoch of observation and to determine the Greenwich date and time of this epoch to the nearest $0^{d}.001$. The local sidereal time of the first and last observations is used in determining the mean epoch. This is converted to Greenwich values as described in paragraph 6-20. Where the observation period exceeds 4 hours, more than one mean epoch must be determined.

(3) The right ascension and declination are extracted from the APFS, which gives apparent position for stars with a declination greater than 81° for every upper transit. Right ascensions are extracted to the nearest $0^{s}.1$ and declinations to the nearest $0''.01$.

For example, we wish to extract α and δ for Polaris (α Ursae Minoris) for an observation. The mean epoch is 30.327 Jun 68. The observation is apparently bracketed by the following times for which the position is given:

Jun 30	$02^{h}\ 00^{m}\ 58^{s}.73$	$89^{\circ}\ 06'\ 52''.47$
Jul 1	02 00 59.95	89 06 52.43

As decimal parts of a day are the interpolating argument it is necessary to find the exact part of the Greenwich Day at which the upper transits were made. This is done by subtracting sidereal time at 0^{h} UT for that day from the right ascension and dividing the result in minutes by 1444. (There are about 1444 sidereal minutes in a mean solar day.)

	30 Jun 68	1 Jul 68
Right ascension	$02^{h}\ 00^{m}\ 58^{s}.7$	$02^{h}\ 00^{m}\ 60^{s}.0$
ST 0^{h} UT	18 32 29.4	18 36 25.9
Sidereal interval	07 28 29.3	07 24 34.1

$$\frac{448.5}{1444} = 0^{d}.311 \qquad \frac{444.6}{1444} = 0^{d}.308$$

Upper transit on: Jun 30.311 and Jul 1.308

PROJECT	LOCATION FT. BELVOIR, VA.	AZIMUTH BY DIRECTION METHOD/SET #2 (TM 5-237)		
ORGANIZATION U.S.A.E.S.	MARK JACKSON Az. Mk. (USAES) 1967	LATITUDE (φ) 38° 41′ 07.″86	LONGITUDE (λ) 05ʰ 08ᵐ 32.ˢ61	STATION JACKSON (USAES) 1967

CHRON. NR. 2729208	INST. (NR.) T3 # 91026	LEVEL VALUE (d/4) 1.812 4	ECC.* (INST.) (SIGNAL) NONE	OBSERVER SSG JONES	G. CIVIL DAY 30.327 JUN 68

Date 19 68 , position	30 JUN (AM) 1	2	3	4
Chronometer reading	20 42 10.7	20 47 09.7	20 51 17.4	20 54 44.8
Chronometer correction	+ 15.0	+ 15.0	+ 15.0	+ 15.0
Sidereal time	20 42 25.7	20 47 24.7	20 51 32.4	20 54 59.8
RA(α) of POLARIS (star)	02 00 58.7	02 00 58.7	02 00 58.7	02 00 58.7
HA(t) of star (time)	18 41 27.0	18 46 26.0	18 50 33.7	18 54 01.1
t of star (arc)				
Decl. (δ) of star	89° 06′ 52.″47			
Constants for star	Sin φ +0.6250 4536	Cos φ +0.7805 8843	Tan δ +64.704 77	Cos φ Tan δ 50.507 795
Sin t	−0.983 6894	−0.979 5460	−0.975 7627	−0.972 3512
Cos t	+0.179 8754	+0.201 2204	+0.218 8316	+0.233 5232
Sin φ cos t				
Cos φ tan δ − sin φ cos t	+50.395 365	+50.382 023	+50.371 015	+50.361 832
$-\text{Tan } A = \frac{\sin t}{\cos\phi \tan\delta - \sin\phi \cos t}$	−0.0195 1944	−0.0194 4237	−0.0193 7151	−0.0193 0730
A (Az. of star from N.)†	+01° 07′ 05.″7	+01° 06′ 49.″8	+01° 06′ 35.″2	+01° 06′ 21.″9
Diff. in time between D. & R.	m. s. 01 22.2	m. s. 01 04.4	m. s. 01 04.8	m. s. 01 05.9
Curvature correction	−9.3 —	−10.4 —	−11.3 —	−12.1 —
Altitude of star (h)	38° 50′ 10″	38° 51′ 20″	38° 52″ 10′	38° 53′ 00″
$\frac{d}{4}$ tan h (level factor)	1.4588	1.4597	1.4605	1.4612
Inclination	+0.1	+0.7	+0.9	+1.1
Level correction	+0.″1	+1.″0	+1.″3	+1.″6
Circle reading on star	12 33 58.0	203 34 05.2	34 34 17.6	225 34 22.7
Corr. reading on star	12 33 58.1	203 34 06.2	34 34 18.9	225 34 24.3
Circle reading on Mark	00 00 24.4	191 00 46.4	22 01 14.7	213 01 34.2
Diff. (Mark minus star)	347 26 26.3	347 26 40.2	347 26 55.8	347 27 09.9
Corr. Az. of star, from N.†	+01 07 05.7	+01 06 49.8	+01 06 35.2	+01 06 21.9
	180° 00′ 00″.0	180° 00′ 00″.0	180° 00′ 00″.0	180° 00′ 00″.0
Azimuth of (clockwise from south)	° ′ ″ 168 33 32.0	° ′ ″ 168 33 30.0	° ′ ″ 168 33 31.0	° ′ ″ 168 33 31.8

To the mean result from the above computation must be applied corrections for diurnal aberration, elevation of mark, and eccentricity (if any) of station and mark. Carry times and angles to tenths of seconds only.
* Give volume and page of record for eccentricity, if any. † Minus, if west of north.

COMPUTED BY SP 5 MARTIN	DATE 2 JULY 68	CHECKED BY ✓ SSG JONES	DATE 2 JULY 68

DA FORM 1 FEB 57 1903

Figure 8–3. Azimuth by direction method (natural functions).

PROJECT

LOCATION FT. BELVOIR, VA.

AZIMUTH BY DIRECTION METHOD (LOGARITHMIC)

(TM 5-237)

SET #2

ORGANIZATION U.S.A.E.S.

MARK JACKSON AZ. MK. (USAES) 67

LATITUDE (φ) 38° 41′ 07.″86

LONGITUDE (λ) 05ʰ 08ᵐ 32.ˢ61

STATION JACKSON (USAES) 1967

CHRON. NR. 2729208

INST. (NR.) T3 #91026

LEVEL VALUE $\frac{(d)}{4}$ 1.812

ECC.* (INST.) (SIGNAL) NONE

OBSERVER SSG JONES

G. CIVIL DAY 30.327 JUN 68

Date 19 68, position	30 JUNE (AM)	2	3	4
Chronometer reading	20 42 10.7	20 47 09.7	20 51 17.4	20 54 44.8
Chronometer correction	+ 15.0	+ 15.0	+ 15.0	+ 15.0
Sidereal time	20 42 25.7	20 47 24.7	20 51 32.4	20 54 59.8
RA(α) of POLARIS (star)	02 00 58.7	02 00 58.7	02 00 58.7	02 00 58.7
HA(t) of star (time)	18 41 27.0	18 46 26.0	18 50 33.7	18 54 01.1
t of star (arc)	10 21 45.0	11 36 30.0	12 38 25.5	13 30 16.5
Decl. (δ) of star	89° 06′ 52.″47			
Log cot δ	8.189 06			
Log tan φ	9.903 49	8.092 55	8.092 55	8.092 55
Log cos t	9.254 97	9.303 67	9.340 11	9.368 33
Log a (to 5 places)	7.347 52	7.396 22	7.432 66	7.460 88
Log cot δ	8.189 064			
Log sec φ	0.107 578	8.296 642	8.296 642	8.296 642
Log sin t	9.992 858 n	9.991 025 n	9.989 344 n	9.987 823 n
Log $\frac{1}{1-a}$	0.000 968	0.001 083	0.001 178	0.001 257
Log (−tan A)(to 6 places)	8.290 468 n	8.288 750 n	8.287 165 n	8.285 722 n
A (Az. of star from N.)†	+01° 07′ 05.″7	+01° 06′ 49.″8	+01° 06′ 35.″2	+01° 06′ 21.″9
Diff. in time between D. & R.	m. s. 01 22.2	m. s. 01 04.4	m. s. 01 04.8	m. s. 01 05.9
Curvature correction	—	—	—	—
Altitude of star (h)	° ′ ″ 38 50 10	° ′ ″ 38 51 20	° ′ ″ 38 52 10	° ′ ″ 38 53 00
$\frac{d}{4}$ tan h (level factor)	1.4588	1.4597	1.4605	1.4612
Inclination	+ 0.1	+0.7	+0.9	+1.1
Level correction	+ 0.1	+ 1.0	+ 1.3	+ 1.6
Circle reading on star	12 33 58.0	203 34 05.2	34 34 17.6	225 34 22.7
Corr. reading on star	12 33 58.1	203 34 06.2	34 34 18.9	225 34 24.3
Circle reading on Mark	00 00 24.4	191 00 46.4	22 01 14.7	213 01 34.2
Diff. (Mark minus star)	347 26 26.3	347 26 40.2	347 26 55.8	347 27 09.9
Corr. Az. of star, from N.†	+01 07 05.7	+01 06 49.8	+01 06 35.2	+01 06 21.9
▨	180° 00′ 00″.0	180° 00′ 00″.0	180° 00′ 00″.0	180° 00′ 00″.0
Azimuth of (clockwise from south)	° ′ ″ 168 33 32.0	° ′ ″ 168 33 30.0	° ′ ″ 168 33 31.0	° ′ ″ 168 33 31.8

To the mean result from the above computation must be applied corrections for diurnal aberration, elevation of mark, and eccentricity (if any) of station and mark. Carry times and angles to tenths of seconds only.

* Give volume and page of record for eccentricity, if any.

† Minus, if west of north.

COMPUTED BY SP5 MARTIN

DATE 2 JULY 68

CHECKED BY SSG JONES

DATE 2 JULY 68

DA FORM 1 FEB 57 1904

Figure 8–4. Azimuth by direction method (logarithms).

(4) The interpolation develops as follows:

$$\begin{array}{llll}
 & & \alpha & \delta \\
\text{Jun } 30.311 & & 02^h\ 00^m\ 58^s.73 & 89^\circ\ 06'\ 52''.47 \\
 & 0^d.016 & & \\
0^d.997 & 30.327 & +01^s.22 & -00''.04 \\
\text{Jul } 1.308 & & 02\ \ 00\ \ 59.95 & 89\ \ 06\ \ 52.43
\end{array}$$

$$\text{Interpolating argument} = n = \frac{0.016}{0.997} = 0.016$$

Jun 30.327 $\alpha = 02^h\ 00^m\ 58^s.7$ $\delta = 89^\circ\ 06'\ 52''.47$
The interpolation of second or higher differences is not necessary.

c. Short period terms of nutation are included in the apparent positions that are listed for every upper transit and need not be applied separately. Because right ascension is carried only to 0ˢ.1 the correction for diurnal aberration is too small to be considered. Diurnal aberration in declination is applied later in the computation.

d. When the right ascension is subtracted from the local sidereal time of observation (adding 24ʰ to the LST if necessary to avoid a negative angle), the result is the local hour angle, "t". Computation of the azimuth "A" is completed using either DA Form 1903 or DA Form 1904 and the signs are checked. For northern stars when the local hour angle is from 0ʰ to 12ʰ the star is west of north and "A" is negative, 12ʰ to 24ʰ the star is east of north and "A" is positive. For southern stars when the local hour angle is from 0ʰ to 12ʰ the star is west of south and "A" is positive, from 12ʰ to 24ʰ the star is east of south and "A" is negative.

8–9. Curvature Correction

a. The time interval between direct and reverse pointings on the star should be as small as possible.

b. In using the direction method of azimuth determination, two pointings are made on the star, one direct and one reverse. The resulting azimuth is computed using the mean of the chronometer times and the mean of the instrument pointings. The azimuth thus computed is the azimuth of the mean hour angle and does not equal the required mean azimuth of the chronometer times of the separate pointings in the observation (fig. 8–5).

c. The rate of change of azimuth constantly varies because of curvature of the apparent path of the star. The difference is small but not always negligible. The general expression for computing the correction is:

$$\Delta A = (\tan A)\,\frac{1}{n}\sum \frac{2\sin^2 \frac{1}{2}\tau}{\sin 1''}$$

Where:

$A =$ the azimuth of the star from the elevated pole

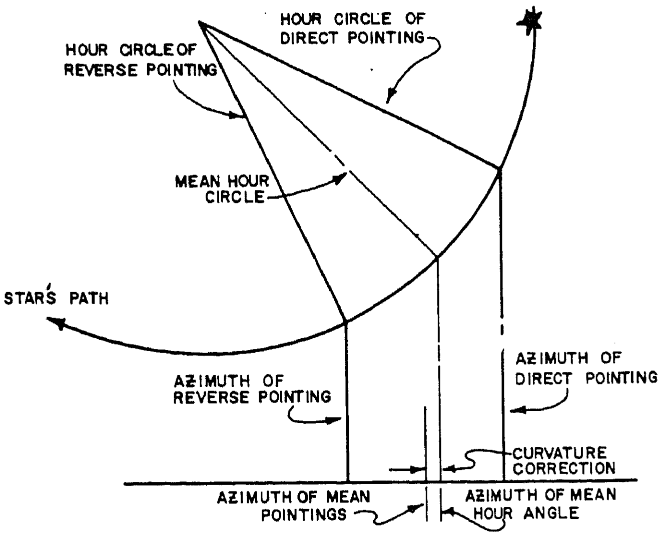

HOUR CIRCLE OF DIRECT POINTING
HOUR CIRCLE OF REVERSE POINTING
MEAN HOUR CIRCLE
STAR'S PATH
AZIMUTH OF REVERSE POINTING
AZIMUTH OF DIRECT POINTING
CURVATURE CORRECTION
AZIMUTH OF MEAN POINTINGS
AZIMUTH OF MEAN HOUR ANGLE

Figure 8–5. Curvature correction.

$n =$ the number of pointings

$\tau =$ the interval between the mean hour angle of all pointings and the hour angle of a single pointing

In the direction method, n = 2 and 2τ is the interval between the direct and reverse pointings on the star. For close circumpolar stars the correction may be taken from table B–15, appendix B. The sign of the curvature correction is such that the angle of the star from the elevated pole is decreased numerically. When other than circumpolar stars are used, table B–15 is not sufficiently extensive and the curvature correction must be either computed or eliminated by computing separately the direct and reverse pointings, and meaning the results. Table B–7, appendix B has been prepared to give the values of:

$$\frac{2\sin \frac{1}{2}\tau}{\sin 1''}$$

with the time interval between direct and reverse pointings as the argument.

8–10. Inclination Correction

a. The angle as measured between two objects not in the same plane will not be a true horizontal angle when the vertical axis of the instrument is not truly vertical. As the inclination of the vertical axis of the difference in altitude between the two objects increases, the error also increases. For this reason the circle readings are corrected by use of the following expression:

$$\text{Corr} = \frac{d}{4}\,[(\Delta 1) - (\Delta r)]\tan h$$

Where:

$d =$ value of the level vial in seconds of arc per graduation

$\Delta l =$ arithmetical difference of the direct and reverse readings of the left end of the level

$\Delta r =$ arithmetical difference of the direct and reverse readings of the right end of the level

$h =$ observed altitude of the object

when the level vial is numbered consecutively from one end to the other. Where the level vial is numbered from the center out rather than consecutively from one end to the other the correction becomes:

$$\text{Corr} = \frac{d}{4}\left[(\Sigma l) - (\Sigma r)\right] \tan h$$

where the readings of the ends of the level have been added rather than subtracted. When the level can be reversed on the instrument a mean of $[(\Delta l) - (\Delta r)]$ with the instrument direct and $[(\Delta l) - (\Delta r)]$ with the instrument reversed is taken. The level correction with the proper sign is added algebraically to the circle reading on the star to give the corrected circle reading.

b. When Polaris has been observed and no measurement of the zenith distance has been made the altitude may be extracted from the AE&NA, table II. When "h" is the desired value the expression becomes:

$$h = \phi - (a_0 + a_1 + a_2)$$

An illustration of the determination of the altitude of Polaris is shown below:

$\phi = 38^\circ\ 41'.1$ LST $= 20^h\ 42^m.4$ Date $=$ 30 Jun 68

$a_0 = -9'.3$ $a_1 = -0'.1$ $a_2 = +0'.3$

$h = 38^\circ\ 41'.1 - (-9'.3 - 0'.1 + 0'.3)$

$= 38^\circ\ 41'.1 + 9'.1 = 38^\circ\ 50'\ 12'' = h$

c. When a star other than Polaris is observed the altitude for each position must be computed from the formula:

$$\cos h = \frac{\cos \delta \sin t}{\sin A} \text{ or}$$

$$\sin h = \sin \phi \ \sin \delta + \cos \phi \cos \delta \cos t$$

Where:

$h =$ the star's altitude

$\delta =$ the star's declination

$t =$ the star's hour angle

$A =$ the star's azimuth

$\phi =$ the observer's latitude

d. As the tangent function is not critical at lower altitudes, it is easiest to compute the altitude as intervals during the observation, graph the function with a time base, and scale the altitude for each observation from the graph.

e. If the mark (signal) is above or below the horizon by more than 1°, level readings must be taken while observing on the mark and the circle readings on the mark must be corrected for inclination by means of the expression:

$$\text{Corr} = \frac{d}{4}\left[(\Delta l) - (\Delta r)\right] \tan H$$

Where:

$d =$ value of the level vial in seconds o arc per graduation

$\Delta l =$ arithmetical difference of the direc and reverse readings of the left end o the level

$\Delta r =$ arithmetical difference of the direc and reverse readings of the right enc of the level

$H =$ the observed angular altitude of th signal

This correction is applied in the same manner the correction to the circle reading on the st Where "H" is an angle of elevation, the tang of "H" is positive; if "H" is an angle of depr sion, the tangent of "H" is negative. When t correction to the circle reading on the mark is be used, it must be applied before the reading the mark is entered on the form.

f. All altitudes need be corrected only to t nearest 10″ and four place values of the tang function are sufficient.

8–11. Azimuth of the Mark

The corrected circle reading on the star is su tracted from the corrected circle reading on t mark (adding 360° if the result would be neg tive), thus obtaining the angle of the mark fr the star. To this angle is added algebraically t corrected azimuth of the star from north (fr south if a southern star is observed). When northern star is observed, 180° must be added give the azimuth from south. Examples of azimu computation using DA Form 1903 and DA For 1904 respectively are illustrated in figure 8–3 ar 8–4.

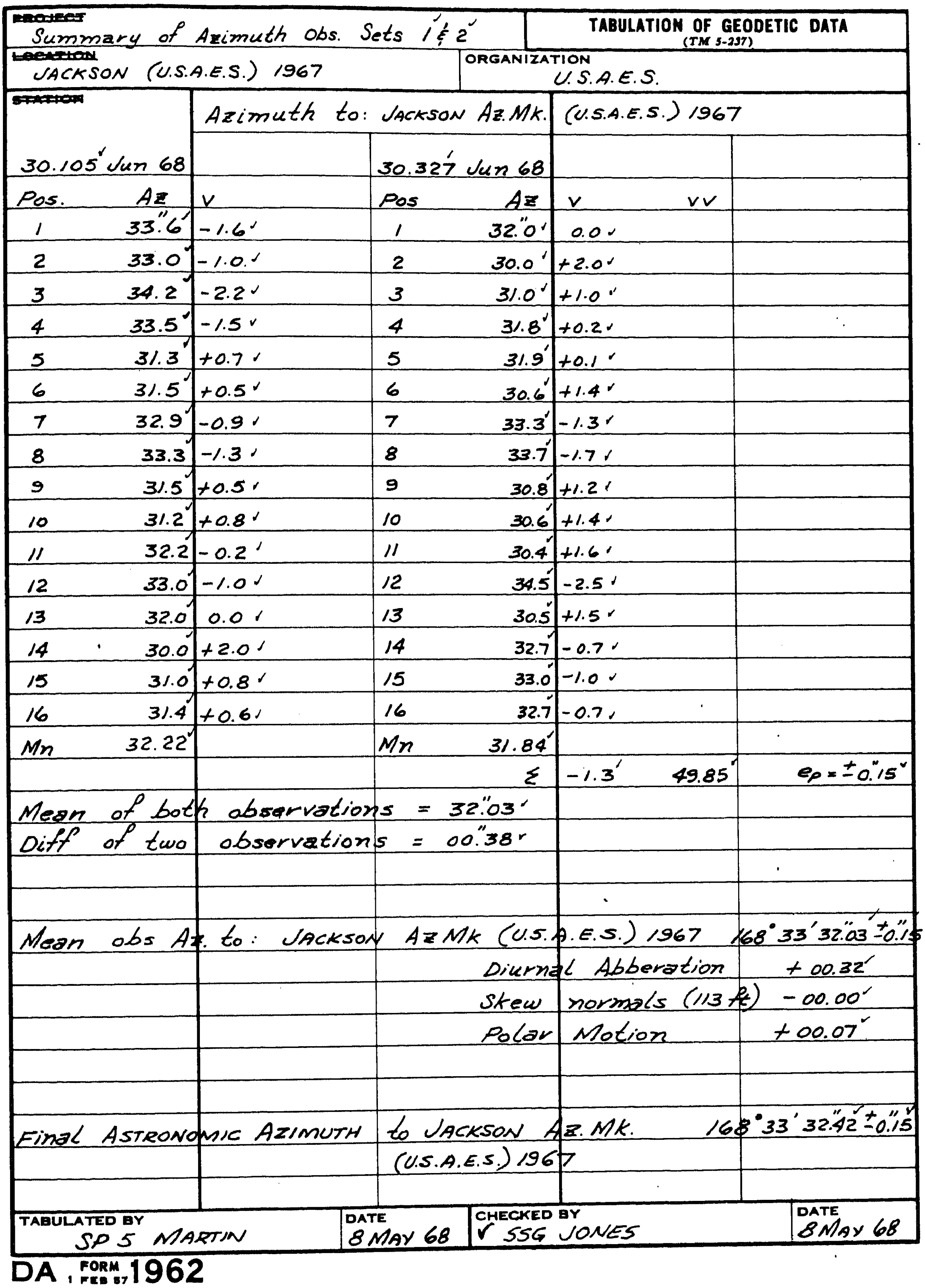
8–12. Azimuth Summary

a. Procedure. After all the azimuths have be computed they are summarized on DA Form 19 (fig. 8–6). Any position having a residual great than ± 5″.00 from the mean is rejected and a ne mean computed. After all rejections have bee made the probable error of the mean azimuth computed from the standard formula:

$$e_m = \pm 0.6745 \sqrt{\frac{[vv]}{n(n-1)}}$$

b. Determination of Mean. A mean of each set determined and if the mean of one set differs fro the mean of the other set by more than 1″.00, an other set must be observed.

c. Corrections. The mean observed azimuth mus be corrected for diurnal aberration in declinatio elevation of the mark, polar variation, and if nec



~~PROJECT~~ Summary of Azimuth Obs. Sets 1 & 2

TABULATION OF GEODETIC DATA
(TM 5-237)

~~LOCATION~~ JACKSON (U.S.A.E.S.) 1967

ORGANIZATION U.S.A.E.S.

~~STATION~~

Azimuth to: JACKSON Az.Mk. (U.S.A.E.S.) 1967

30.105 Jun 68			30.327 Jun 68				
Pos.	Az	v	Pos	Az	v	vv	
1	33.″6	-1.6	1	32.″0	0.0		
2	33.0	-1.0	2	30.0	+2.0		
3	34.2	-2.2	3	31.0	+1.0		
4	33.5	-1.5	4	31.8	+0.2		
5	31.3	+0.7	5	31.9	+0.1		
6	31.5	+0.5	6	30.6	+1.4		
7	32.9	-0.9	7	33.3	-1.3		
8	33.3	-1.3	8	33.7	-1.7		
9	31.5	+0.5	9	30.8	+1.2		
10	31.2	+0.8	10	30.6	+1.4		
11	32.2	-0.2	11	30.4	+1.6		
12	33.0	-1.0	12	34.5	-2.5		
13	32.0	0.0	13	30.5	+1.5		
14	30.0	+2.0	14	32.7	-0.7		
15	31.0	+0.8	15	33.0	-1.0		
16	31.4	+0.6	16	32.7	-0.7		
Mn	32.22		Mn	31.84			
				Σ	-1.3	49.85	$e_p = \pm 0.''15$

Mean of both observations = 32.″03

Diff of two observations = 00.″38

Mean obs Az. to: JACKSON Az Mk (U.S.A.E.S.) 1967 168° 33′ 32.″03 ± 0.″15

Diurnal Abberation + 00.32

Skew normals (113 ft) - 00.00

Polar Motion + 00.07

Final ASTRONOMIC AZIMUTH to JACKSON Az. Mk. (U.S.A.E.S.) 1967 168° 33′ 32.″42 ± 0.″15

TABULATED BY	DATE	CHECKED BY	DATE
SP 5 MARTIN	8 MAY 68	✓ SSG JONES	8 MAY 68

DA FORM 1 FEB 57 1962

Figure 8–6. Azimuth summary.

essary for eccentricity of the instrument or the mark.

d. Diurnal Aberration. Because of the movement of the observer owing to the earth's rotation on its axis and the variation in the speed of that movement with the observer's latitude, a star is seen slightly displaced from its real position (para 6–16*d*). The correction to the apparent declination for a star at any hour angle may be written in the form:

diurnal aberration $\delta = k_\delta = 0''.32 \cos\phi \sin t \sin\delta$

However, since only one star is observed in azimuth determination the expression is rewritten as a correction that is applied to the azimuth of that star, as follows:

$$k = 0''.32 \frac{\cos A \cos\phi}{\cos h}$$

Where:

A = the azimuth angle of the star clockwise from the pole

ϕ = the observer's latitude

h = observed altitude of the star

The correction is not applied to the individual observations but to the entire set using the mean azimuth and mean altitude. For very close circumpolar stars the expression to be used is:

$$k = 0''.32 \cos A$$

For azimuths measured clockwise, the correction is positive in the northern hemisphere and negative in the southern hemisphere.

e. Elevation of the Mark. Since the verticals of any two points on a spheroid do not, in general, lie in the same plane, there will be an error in the observed horizontal direction of a station, depending upon its height above the spheroid. This error may be likened to the error of sighting on an inclined range pole; the higher up the sight is taken, the greater the error in the horizontal direction. This causes a correction in seconds of arc to the azimuth, the correction being dependent on the elevation of the mark. This correction is also known as the "skew normal" correction. The first approximation of the correction is:

$$\Delta A = + \frac{e^2 h}{2a \sin 1''} \cos^2\phi \sin 2A$$

Where:

e = the eccentricity of the spheroid of reference

a = the semimajor axis of the spheroid of reference

ϕ = the latitude of the point of observation

A = the azimuth of the mark from south

h = the elevation of the mark above sea level, expressed in the same terms as "e" and "a"

See paragraph 7–8*e*(2) for double angle formula. The correction may be computed for all spheroids from:

$$\Delta A = 0.000109\, h \cos^2\phi \sin 2A$$

where h is in meters. The sign of the correction is positive when "A" is in the first or third quadrants and negative when "A" is in the second or fourth quadrants. In other words, it is positive when the mark is northeast or southwest and negative when the mark is northwest or southeast.

f. Polar Variation. The observed azimuth must be corrected for polar variation as explained in paragraph 6–28. The correction is given by:

$$\Delta A = (x \sin\lambda - y \cos\lambda) \sec\phi$$

g. Eccentricity. If either the instrument or mark were eccentric to the station to which the azimuth is referred, the observed azimuth must be reduced to the azimuth between the referenced stations. The field party must determine the eccentric angle and distance at the eccentric station and the distance between the instrument and the signal. The reduction is called "reduction to center" and is fully explained in TM 5–237.

Section II. EAST-WEST STARS

8–13. General

a. In the very low latitudes, generally defined as between N 5° and S 10°, circumpolar stars cannot be readily observed. The azimuth determination consists of observations on east and west stars symmetrically about their position of minimum azimuthal velocity (elongation), where such star positions occur between altitudes of approximately 12° to 18°. If close circumpolar stars are visible at these latitudes, they should be observed in preference to the east-west star method.

b. In azimuth determination using east-west stars the station latitude is critical, hence the astronomic latitude must be accurately determined and used in the computation. Similarly, the astronomic longitude should be determined and used in the computation; however, the effect of using the geodetic longitude is less critical.

8–14. Specifications

a. First Order.

(1) The azimuth is determined from the mean of a minimum of 48 acceptable observations, conducted on at least two different nights or with two

observing periods separated by at least 4 hours.

(2) The number of acceptable observations is divided equally between east and west stars.

(3) Any observation with a residual greater than ± 5″.00 from the mean of the stars in that set is rejected. A set pertains to the observations on one star during an observing period.

(4) The probable error of the final result of all observations must not exceed ± 0″.30. Additional observations are made if this probable error is exceeded.

(5) The probable error of the final result is computed from:

$$e_p = \pm \sqrt{\frac{(e_pW)^2 + (e_pE)^2}{4}}$$

Where:

e_pW = the probable error of the mean of the observations on the west star(s)

e_pE = the probable error of the mean of the observations on the east star(s)

(6) On any one night both an east and a west star are normally observed. The same two stars may be observed on the second night.

(7) If atmospheric conditions prevent observations on both an east and a west star, either east or west stars may be observed provided that stars on the opposite side are observed on another night.

(8) Sixteen positions are normally observed on each star. A star set consisting of less than 12 but not less than eight positions is acceptable providing that a sufficient number of stars are observed to satisfy the requirement of 48 acceptable observations.

(9) The mean azimuth of any one set of observations may not differ by more than ± 1″.00 from the mean azimuth of the east or west sets.

(10) If the astronomic position is *not* used in the field computation the following criteria will apply.

(*a*) The mean azimuth of any set of observations on an east (west) star shall not vary from the mean of all sets of east (west) stars by more than ±1″.00.

(*b*) A paired set, consisting of the mean azimuth of the observations of both an east and west star, shall not vary from the mean of a second paired set by more than ± 1″.00.

b. Second Order.

(1) The azimuth is determined from the mean of a minimum of 24 acceptable observations.

(2) The number of acceptable observations must be divided equally between east and west stars.

(3) Sixteen positions are observed on each star, with a minimum of 12 acceptable positions.

(4) Any observation with a residual greater than ±5″.00 from the mean of the set is rejected. A set pertains to the observation on one star.

(5) The probable error of the final result of all observations must not exceed ± 0″.50. The probable error is computed using the formula in *a*(5) above.

(6) With the exception of the above specifications all other specifications listed in *a* above apply.

c. Third Order. For specifications, procedures, and methods for third order see chapter 8, TM 5-441.

8-15. Determination of Suitable Stars for Observation

a. Stars are selected such that their positions of elongation occur at approximately 12° to 18° altitude, thus permitting their observation about elongation between 5° and 25° altitude.

b. When the station latitude is greater than ±2° the declination range for elongating stars is from 3½ to 5 times the station latitude. This will place the altitude of elongation within the range of 12° to 18°.

c. When the station latitude is within 2° of the equator, the range of suitable declinations of elongating stars is quite narrow and in order to increase this range, observations may also be made on stars near the prime vertical.

d. The declination of the selected stars must be in the same hemisphere as the station latitude.

e. Since the stars should be readily visible to the unaided eye, a magnitude range of 1.0 to 4.5 is recommended; however, stars of dimmer magnitude may be used if conditions permit.

f. Observations are begun at a time that insures a symmetric distribution of positions about the star's point of elongation.

8-16. Determination of Suitable Declinations

a. Elongating stars suitable for observation have a declination lying between three and one-half and five times the station latitude. Hence, with a station latitude of S 02° 35′ the declination range is from −09° to −13°.

b. The prime vertical stars have a declination between the equator and the station latitude but should preferably have a declination of about ½ the station latitude.

c. Hence, at a station latitude of N 00° 50′ the declination range will be from 0° to + 00° 50′ for prime vertical stars as well as from + 02° 55′ to + 04° 10′ for elongating stars.

8–17. Observing List

In selecting stars suitable for observation, many approximations are made. When the stars are selected the data are refined.

a. Right Ascension.

(1) First the local sidereal time when observations are to commence must be determined. The stars to be observed will be about $\frac{1}{2}$ hour above the horizon at either start or conclusion of observation. Hence, the right ascension of an east/west star at the start of observation would be LST $+ 5\frac{1}{2}$ hr/LST $- 4\frac{1}{2}$ hr, assuming a 1-hour observing period. The required hour angles may be obtained with sufficient accuracy by computing the hour angle on the horizon and then correcting it for the required altitude in hours. With ϕ and δ of 0° the hour angle of a star on the horizon is 6 hours and at $\phi = 10°$ and $\delta = 45°$ the hour angle would be about $6^h\ 40^m$. Therefore, the hour angle of the east stars should be about $-5\frac{1}{2}^h$ near the equator and about -6^h at $\phi = 10°$. Based on a 1-hour observing period, the west stars should be near hour angles $4\frac{1}{2}^h$ and 5^h respectively. A linear interpolation between these extremes is sufficient for preparing the star list.

(2) The catalog is entered, starting at the proper right ascension, and those stars within the declination range and having a suitable magnitude are selected. A sufficient number of stars is listed in two columns, west and east, according to increasing right ascension. An example of the preliminary list is shown below:

WEST

Star	Mag	α	δ
190	4.3	$05^h\ 08^m$	$-08°\ 48'$
194	0.3	05 13	−08 14
220	2.2	05 46	−09 41
266	4.2	06 53	−12 00
293	4.1	07 40	−09 28

EAST

Star	Mag	α	δ
564	2.7	$15^h\ 15^m$	$-09°\ 16'$
622	2.7	16 35	−10 30
673	3.5	17 57	−09 46
1482	4.1	18 33	−08 16
1527	4.6	20 16	−12 37

b. Preselecting Stars. Choose by inspection a pair of stars, one east and one west, which will arrive at the proper hour angle in the correct sequence; that is, so that one is approaching the position for beginning observations at the time observing is completed on the other. For example, an east star comes into proper position first. Then, the west star should have a right ascension so as to arrive in position 1 hour (or other length of observation period) later. One way of doing this is to subtract the hour angle used from the right ascension of the east star, and to add the hour angle to the right ascension of the west star. This gives the LST at which they will arrive in position. The LST of one should follow that of the other by at least the observing period, ordinarily 1 hour.

c. Alternate Pairs. As a precaution, select one or more alternate pairs to serve in case observations on the first are interrupted by clouds or other causes. The star tables seldom afford an ideal pair at just the desired time.

Station: PILIKOS $\phi = S\ 02°\ 35'\ 16''$
$\lambda = W\ 10^h\ 01^m\ 19^s$
Date: Local 5 May 68 LST obs start $08^h\ 51^m$
δ Range −08° to −13°
α Range E $= 08^h\ 51^m + 5^h\ 30^m = 14^h\ 21^m$
W $= 08^h\ 51^m - 4^h\ 30^m = 04^h\ 21^m$

The list may have to be continued and the observations delayed until suitable stars are found. This will seldom prove serious.

8–18. Computation of Star Finding Data

a. The time, magnitude, altitude, and approximate azimuth of the stars must be known in order to find and identify them. Since the field of the telescope is a degree or more in width, these operations do not have to be done with high precision.

b. The hour angle of elongation is found by:

$$\cos t_e = \tan \phi \cot \delta$$

Add this hour angle to the star's right ascension to obtain the LST of elongation. Then the observing period begins $\frac{1}{2}$ hour before the time of elongation.

c. The altitude of elongation is found by:

$$\sin h_e = \frac{\sin \phi}{\sin \delta}$$

In the case of an east star, one-half the observing period converted to arc units is subtracted from the altitude of elongation to obtain the altitude for finding the star and starting observations. For a west star, the half interval is added to the altitude of elongation. Assuming a 1-hour period, this amount would be 7° 30′.

d. The azimuth of elongation is given by:

$$\sin A_e = \frac{\cos \delta}{\cos \phi}$$

This azimuth is sufficient for finding the star at the time of beginning observations. This presupposes a knowledge of the approximate azimuth of the mark. If no ground direction is available, an approximate azimuth by such observations as on the sun, or with a good magnetic compass, must be obtained before the observing period.

e. To find the star, at the LST for the beginning pointings, set the vertical circle to the altitude for this time, and place the telescope at the proper azimuth. Because of the approximate nature of the calculations, some movement of the line of sight may be required. However, the star will be the brightest in the immediate vicinity as well as very close to the set position. Little difficulty should be encountered in positively identifying the star. The star is found on successive positions by adding the advancement of the circle to the last reading on the star and usually without setting the altitude. An example of an observing list is shown below:

Star	Mag	E–W	t	Begin	Az	Alt
190	4.3	W	$04^h\,55^m$	$09^h\,33^m$	81° 35′	17° 11′
220	2.2	W	04 59	10 15	80 40	15 35
622	2.7	E	05 02	11 03	289 10	14 22
293	4.1	W	04 57	12 07	80 39	15 57
1482	4.1	E	04 47	13 16	277 52	18 19

8–19. Observations

Observing procedure is exactly the same as for observing a circumpolar star. The 1-hour observing period should allow 16 positions to be observed. This period should not exceed 1 hour at latitudes greater than 6°, but may be extended somewhat when near the equator.

8–20. Computation of Azimuth

a. The only difference between extracting the apparent declination and right ascension of the stars observed by the east-west method and circumpolar stars is that the positions listed in the APFS are only tabulated for every 10th day rather than every day. The tabulated days and decimal parts of a day must be expanded to three decimal places. This is done by subtracting the sidereal time at 0^h UT for that day from the right ascension of the star for that day and dividing the result by 1444 minutes. In addition, the second difference and short period terms of nutation in declination must be computed and applied.

For Star 220		Mean epoch 5.410 May 68
	2.6 May 68	12.6 May 68
Right ascension =	$05^h\,46^m\,13\overset{s}{.}855$	$05^h\,46^m\,13\overset{s}{.}794$
ST 0^h UT =	14 39 52.461	15 19 18.011
Sidereal interval =	15 06 21.394	14 26 55.783

$$\frac{906.357}{1444} = 0.6278 \qquad \frac{866.930}{1444} = 0.6003$$

May 2.6278
2.7822
May 5.410
9.9725
May 12.6003

α
$05^h\,46^m\,13.855$
-0.061
$13\overset{s}{.}794$

δ
$-\,09°\,40'\,46\overset{''}{.}36$
$+1.29$
$45\overset{''}{.}07$

$$n = \frac{2.7822}{9.9725} = 0.279 \quad B'' = \frac{n(n-1)}{4} = -\,0.050$$

$$d\Psi = +\,0.130 \qquad d\varepsilon = -\,0.019 \quad \Delta\delta = -\,0.02$$

$$(\Delta_0'' + \Delta_1'') = +\,0.42$$

$$\alpha = 05^h\,46^m\,13\overset{s}{.}8 \qquad \delta = -\,09°\,40'\,46\overset{''}{.}04$$

b. As the tables of "log 1/1–a" are not sufficiently extensive, only DA Form 1903 is used to compute the azimuth (fig. 8–7). Because the star's azimuth will be at an angle of 40° to 90° from the meridian, the equation for computing its azimuth should be in the form:

$$-\cot A = \frac{\cos\phi\tan\delta - \sin\phi\cos t}{\sin t}$$

Which may be reduced to:

$$-\cot A = \frac{\cos\phi\tan\delta}{\sin t} - \frac{\sin\phi}{\tan t}$$

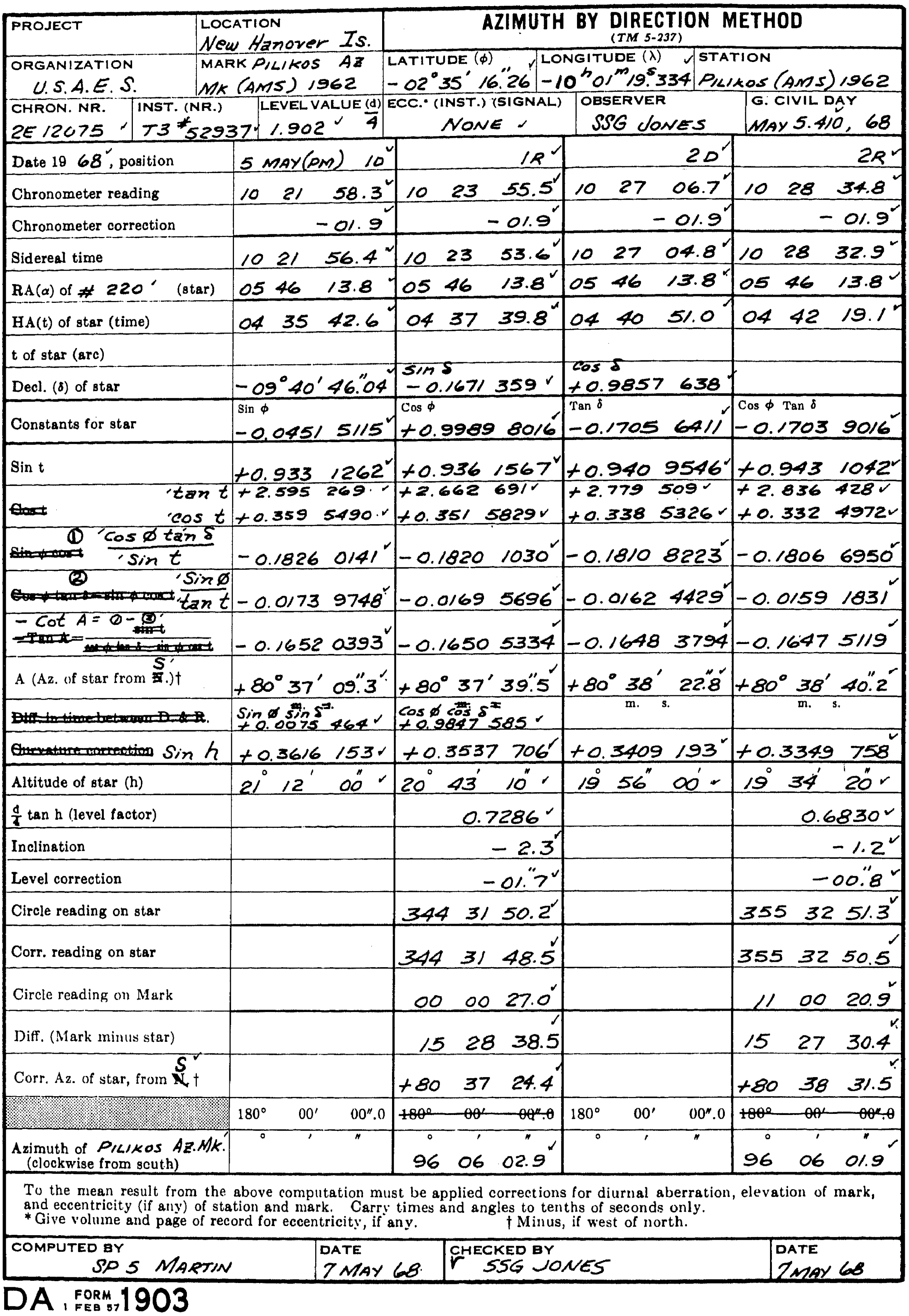
c. The curvature correction in the east-west method of observation is usually relatively large and the expression given in paragraph 8–9 will not give sufficient accuracy. The formula (for two pointings with a direction instrument) is:

$$\Delta A = -\frac{\sin A\cos\phi\ \sec^2 h\,(\cos h\sin\delta - 2\cos A\cos\phi)\,(t)^2\sin 1''}{8}$$

where "t" is the time interval between the two pointings expressed in units of arc. It is much simpler to eliminate the curvature correction by computing the azimuth of the star for both the direct and reverse pointing and then applying the corrected mean circle reading to the mean of the two azimuths.

d. The correction for diurnal aberration in declination is applied to the mean of all observations of a single star using the mean azimuth and altitude of that star.

e. The corrections for elevation of the mark, polar variation, and eccentricity are applied as explained in paragraph 8–12.



AZIMUTH BY DIRECTION METHOD

(TM 5-237)

PROJECT

LOCATION New Hanover Is.

ORGANIZATION U.S.A.E.S.

MARK Pilikos Az Mk (AMS) 1962

LATITUDE (φ) −02°35′16.″26

LONGITUDE (λ) −10ʰ01ᵐ19.ˢ334

STATION Pilikos (AMS) 1962

CHRON. NR. 2E 12075

INST. (NR.) T3 #52937

LEVEL VALUE (d/4) 1.902 4

ECC.* (INST.) (SIGNAL) None

OBSERVER SSG Jones

G. CIVIL DAY May 5.410, 68

Date 19 68, position	5 May (PM) 1D	1R	2D	2R
Chronometer reading	10 21 58.3	10 23 55.5	10 27 06.7	10 28 34.8
Chronometer correction	−01.9	−01.9	−01.9	−01.9
Sidereal time	10 21 56.4	10 23 53.6	10 27 04.8	10 28 32.9
RA(α) of # 220 (star)	05 46 13.8	05 46 13.8	05 46 13.8	05 46 13.8
HA(t) of star (time)	04 35 42.6	04 37 39.8	04 40 51.0	04 42 19.1
t of star (arc)				
Decl. (δ) of star	−09°40′46.″04	Sin δ −0.1671 359	Cos δ +0.9857 638	
Constants for star	Sin φ −0.0451 5115	Cos φ +0.9989 8016	Tan δ −0.1705 6411	Cos φ Tan δ −0.1703 9016
Sin t	+0.933 1262	+0.936 1567	+0.940 9546	+0.943 1042
~~Cos t~~ 'tan t 'cos t	+2.595 269 +0.359 5490	+2.662 691 +0.351 5829	+2.779 509 +0.338 5326	+2.836 428 +0.332 4972
~~Sin φ cos t~~ ① 'Cos Ø tan δ / 'Sin t	−0.1826 0141	−0.1820 1030	−0.1810 8223	−0.1806 6950
~~Cos φ tan δ − sin φ cos t~~ ② 'Sin Ø / tan t	−0.0173 9748	−0.0169 5696	−0.0162 4429	−0.0159 1831
− Cot A = ① − ②' ~~−Tan A = sin t / cos φ tan δ − sin φ cos t~~	−0.1652 0393	−0.1650 5334	−0.1648 3794	−0.1647 5119
A (Az. of star from S ~~N~~.)†	+80°37′09.″3	+80°37′39.″5	+80°38′22.″8	+80°38′40.″2
~~Diff. in time between D. & R.~~	Sin Ø sin δ ~~m. s.~~ +0.0075 464	Cos Ø cos δ ~~m. s.~~ +0.9847 585	m. s.	m. s.
~~Curvature correction~~ Sin h	+0.3616 153	+0.3537 706	+0.3409 193	+0.3349 758
Altitude of star (h)	21° 12′ 00″	20° 43′ 10″	19° 56″ 00′	19° 34′ 20″
d/4 tan h (level factor)		0.7286		0.6830
Inclination		−2.3		−1.2
Level correction		−01.″7		−00.″8
Circle reading on star		344 31 50.2		355 32 51.3
Corr. reading on star		344 31 48.5		355 32 50.5
Circle reading on Mark		00 00 27.0		11 00 20.9
Diff. (Mark minus star)		15 28 38.5		15 27 30.4
Corr. Az. of star, from S ~~N~~ †		+80 37 24.4		+80 38 31.5
▨	180° 00′ 00″.0	~~180° 00′ 00″.0~~	180° 00′ 00″.0	~~180° 00′ 00″.0~~
Azimuth of Pilikos Az.Mk. (clockwise from south)	° ′ ″	° ′ ″ 96 06 02.9	° ′ ″	° ′ ″ 96 06 01.9

To the mean result from the above computation must be applied corrections for diurnal aberration, elevation of mark, and eccentricity (if any) of station and mark. Carry times and angles to tenths of seconds only.
* Give volume and page of record for eccentricity, if any. † Minus, if west of north.

COMPUTED BY SP 5 Martin

DATE 7 May 68

CHECKED BY SSG Jones

DATE 7 May 68

DA FORM 1 FEB 57 1903

Figure 8–7. Computation of azimuth (east-west method).

APPENDIX A

REFERENCES

A-1. Army Regulations

AR 117-5	Military Mapping and Geodesy
AR 310-25	Dictionary of United States Army Terms
AR 310-34	Organization and Equipment, Authorization Tables Equipment
AR 320-50	Authorized Abbreviations and Brevity Codes

A-2. DA Pamphlets

DA Pam 108-1	Index of Army Films, Transparencies, GTA Charts, and Recordings
DA Pam 310 Series	Military Publications Indexes

A-3. Field Manuals

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SP 242	Definitions of Terms Used in Geodetic and Other Surveys
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	Apparent Places of Fundamental Stars (Heidelberg: Astronomisches Rechen-Institut)
	General Catalogue (5 volumes) of 33,342 Stars for the Epoch 1950 (Carnegie Institution of Washington, D.C.)
	Smithsonian Astrophysical Observatory Star Catalogue (4 volumes) (Smithsonian Institute)
	Explanatory Supplement to the Ephemeris (HMSO, London, England)
	Geodesy, Bomford; 2nd Edition (Oxford University Press, Amen House, London, England)
	Spherical and Practical Astronomy; Chauvenet; (2 volumes) (Dover Publications, NYC)
	Compendium of Spherical Astronomy; Newcomb; (Dover Publications, NYC)
	Practical Astronomy; Nassau; (McGraw-Hill Book Co., NYC)
	Spherical and Practical Astronomy as Applied to Geodesy; Mueller; (UNGAR Publishing Co., NYC)

APPENDIX B

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Table B-1. Factors For Star Transit Reduction (A,B,C)

TOP ARGUMENT=STAR'S DECLINATION, δ

SIDE ARGUMENT=STAR'S ZENITH DISTANCE, ζ

[For factor *A* use left-hand argument. For factor *B* use right-hand argument. Factor *C* is on bottom line of next page]

δ ζ	0°	10°	15°	20°	22°	24°	26°	28°	30°	32°	34°	36°	38°	40°	41°	42°	δ ζ
°																	°
1	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	89
2	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.05	.05	.05	88
3	.05	.05	.05	.06	.06	.06	.06	.06	.06	.06	.06	.06	.07	.07	.07	.07	87
4	.07	.07	.07	.07	.08	.08	.08	.08	.08	.08	.08	.09	.09	.09	.09	.09	86
5	.09	.09	.09	.09	.09	.10	.10	.10	.10	.10	.10	.11	.11	.11	.11	.12	85
6	.11	.11	.11	.11	.11	.11	.12	.12	.12	.12	.13	.13	.13	.14	.14	.14	84
7	.12	.12	.13	.13	.13	.13	.14	.14	.14	.14	.15	.15	.15	.16	.16	.16	83
8	.14	.14	.14	.15	.15	.15	.16	.16	.16	.16	.17	.17	.18	.18	.18	.19	82
9	.16	.16	.16	.17	.17	.17	.17	.18	.18	.18	.19	.19	.20	.20	.21	.21	81
10	.17	.18	.18	.19	.19	.19	.19	.20	.20	.21	.21	.21	.22	.23	.23	.23	80
11	.19	.19	.20	.20	.21	.21	.21	.22	.22	.23	.23	.24	.24	.25	.25	.26	79
12	.21	.21	.22	.22	.22	.23	.23	.24	.24	.25	.25	.26	.26	.27	.27	.28	78
13	.22	.23	.23	.24	.24	.25	.25	.26	.26	.27	.27	.28	.29	.29	.30	.30	77
14	.24	.25	.25	.26	.26	.27	.27	.27	.28	.29	.29	.30	.31	.32	.32	.33	76
15	.26	.26	.27	.28	.28	.28	.29	.29	.30	.31	.31	.32	.33	.34	.34	.35	75
16	.28	.28	.29	.29	.30	.30	.31	.31	.32	.33	.33	.34	.35	.36	.37	.37	74
17	.29	.30	.30	.31	.31	.32	.33	.33	.34	.34	.35	.36	.37	.38	.39	.39	73
18	.31	.31	.32	.33	.33	.33	.34	.35	.36	.36	.37	.38	.39	.40	.41	.42	72
19	.33	.33	.34	.35	.35	.36	.36	.37	.38	.38	.39	.40	.41	.42	.43	.44	71
20	.34	.35	.35	.36	.37	.37	.38	.39	.40	.40	.41	.42	.43	.45	.45	.46	70
21	.36	.36	.37	.38	.39	.39	.40	.41	.41	.42	.43	.44	.45	.47	.47	.48	69
22	.37	.38	.39	.40	.40	.41	.42	.42	.43	.44	.45	.46	.48	.49	.50	.50	68
23	.39	.40	.41	.42	.42	.43	.44	.44	.45	.46	.47	.48	.50	.51	.52	.53	67
24	.41	.41	.42	.43	.44	.45	.45	.46	.47	.48	.49	.50	.52	.53	.54	.55	66
25	.42	.43	.44	.45	.46	.46	.47	.48	.49	.50	.51	.52	.54	.55	.56	.57	65
26	.44	.45	.45	.47	.47	.48	.49	.50	.51	.52	.53	.54	.56	.57	.58	.59	64
27	.45	.46	.47	.48	.49	.50	.51	.51	.52	.54	.55	.56	.58	.59	.60	.61	63
28	.47	.48	.49	.50	.51	.51	.52	.53	.54	.55	.57	.58	.60	.61	.62	.63	62
29	.48	.49	.50	.52	.52	.53	.54	.55	.56	.57	.58	.60	.61	.63	.64	.65	61
30	.50	.51	.52	.53	.54	.55	.56	.57	.58	.59	.60	.62	.63	.65	.66	.67	60
31	.52	.52	.53	.55	.56	.56	.57	.58	.59	.61	.62	.64	.65	.67	.68	.69	59
32	.53	.54	.55	.56	.57	.58	.59	.60	.61	.63	.64	.65	.67	.69	.70	.71	58
33	.55	.55	.56	.58	.59	.60	.61	.62	.63	.64	.66	.67	.69	.71	.72	.73	57
34	.56	.57	.58	.59	.60	.61	.62	.63	.65	.66	.67	.69	.71	.73	.74	.75	56
35	.57	.58	.59	.61	.62	.63	.64	.65	.66	.68	.69	.71	.73	.75	.76	.77	55
36	.59	.60	.61	.63	.63	.64	.65	.67	.68	.69	.71	.73	.75	.77	.78	.79	54
37	.60	.61	.62	.64	.65	.66	.67	.68	.70	.71	.73	.74	.76	.79	.80	.81	53
38	.62	.63	.64	.66	.66	.67	.69	.70	.71	.73	.74	.76	.78	.80	.82	.83	52
39	.63	.64	.65	.67	.68	.69	.70	.71	.73	.74	.76	.78	.80	.82	.83	.85	51
40	.64	.65	.67	.68	.69	.70	.72	.73	.74	.76	.77	.79	.82	.84	.85	.86	50
41	.66	.67	.68	.70	.71	.72	.73	.74	.76	.77	.79	.81	.83	.86	.87	.88	49
42	.67	.68	.69	.71	.72	.73	.74	.76	.77	.79	.81	.83	.85	.87	.89	.90	48
43	.68	.69	.71	.73	.74	.75	.76	.77	.79	.80	.82	.84	.86	.89	.90	.92	47
44	.69	.71	.72	.74	.75	.76	.77	.79	.80	.82	.84	.86	.88	.91	.92	.93	46
45	.71	.72	.73	.75	.76	.77	.79	.80	.82	.83	.85	.87	.90	.92	.94	.95	45
	0°	10°	15°	20°	22°	24°	26°	28°	30°	32°	34°	36°	38°	40°	41°	42°	

Table B-1. Factors For Star Transit Reduction (A,B,C)-Continued

TOP ARGUMENT=STAR'S DECLINATION, δ

SIDE ARGUMENT=STAR'S ZENITH DISTANCE, ζ

[For factor *A* use left-hand argument. For factor *B* use right-hand argument. Factor *C* is on line opposite ζ=90°]

ζ \ δ	0°	10°	15°	20°	22°	24°	26°	28°	30°	32°	34°	36°	38°	40°	41°	42°	δ / ζ
°																	°
46	0.72	0.73	0.74	0.77	0.78	0.79	0.80	0.82	0.83	0.85	0.87	0.89	0.91	0.94	0.95	0.97	44
47	.73	.74	.76	.78	.79	.80	.81	.83	.84	.86	.88	.90	.93	.95	.97	.98	43
48	.74	.76	.77	.79	.80	.81	.83	.84	.86	.88	.90	.92	.94	.97	.98	1.00	42
49	.75	.77	.78	.80	.81	.83	.84	.86	.87	.89	.91	.93	.96	.99	1.00	1.02	41
50	.77	.78	.79	.82	.83	.84	.85	.87	.89	.90	.92	.95	.97	1.00	1.01	1.03	40
51	.78	.79	.80	.83	.84	.85	.87	.88	.90	.92	.94	.96	.99	1.01	1.03	1.05	39
52	.79	.80	.82	.84	.85	.86	.88	.89	.91	.93	.95	.97	1.00	1.03	1.04	1.06	38
53	.80	.81	.83	.85	.86	.87	.89	.91	.92	.94	.96	.99	1.01	1.04	1.06	1.07	37
54	.81	.82	.84	.86	.87	.89	.90	.92	.93	.95	.98	1.00	1.03	1.06	1.07	1.09	36
55	.82	.83	.85	.87	.88	.90	.91	.93	.95	.97	.99	1.01	1.04	1.07	1.08	1.10	35
56	.83	.84	.86	.88	.89	.91	.92	.94	.96	.98	1.00	1.02	1.05	1.08	1.10	1.12	34
57	.84	.85	.87	.89	.90	.92	.93	.95	.97	.99	1.01	1.04	1.06	1.09	1.11	1.13	33
58	.85	.86	.88	.90	.91	.93	.94	.96	.98	1.00	1.02	1.05	1.08	1.11	1.12	1.14	32
59	.86	.87	.89	.91	.92	.94	.95	.97	.99	1.01	1.03	1.06	1.09	1.12	1.14	1.15	31
60	.87	.88	.90	.92	.93	.95	.96	.98	1.00	1.02	1.04	1.07	1.10	1.13	1.15	1.17	30
61	.87	.89	.91	.93	.94	.96	.97	.99	1.01	1.03	1.05	1.08	1.11	1.14	1.16	1.18	29
62	.88	.90	.91	.94	.95	.97	.98	1.00	1.02	1.04	1.06	1.09	1.12	1.15	1.17	1.19	28
63	.89	.91	.92	.95	.96	.98	.99	1.01	1.03	1.05	1.07	1.10	1.13	1.16	1.18	1.20	27
64	.90	.91	.93	.96	.97	.98	1.00	1.02	1.04	1.06	1.08	1.11	1.14	1.17	1.19	1.21	26
65	.91	.92	.94	.96	.98	.99	1.01	1.03	1.05	1.07	1.09	1.12	1.15	1.18	1.20	1.22	25
66	.91	.93	.95	.97	.99	1.00	1.02	1.04	1.06	1.08	1.10	1.13	1.16	1.19	1.21	1.23	24
67	.92	.94	.95	.98	.99	1.01	1.02	1.04	1.06	1.09	1.11	1.14	1.17	1.20	1.22	1.24	23
68	.93	.94	.96	.99	1.00	1.02	1.03	1.05	1.07	1.09	1.12	1.15	1.18	1.21	1.23	1.25	22
69	.93	.95	.97	.99	1.01	1.02	1.04	1.06	1.08	1.10	1.13	1.15	1.18	1.22	1.24	1.26	21
70	.94	.95	.97	1.00	1.01	1.03	1.05	1.06	1.09	1.11	1.13	1.16	1.19	1.23	1.25	1.26	20
71	.95	.96	.98	1.01	1.02	1.04	1.05	1.07	1.09	1.12	1.14	1.17	1.20	1.23	1.25	1.27	19
72	.95	.97	.98	1.01	1.03	1.04	1.06	1.08	1.10	1.12	1.15	1.17	1.21	1.24	1.26	1.28	18
73	.96	.97	.99	1.02	1.03	1.05	1.06	1.08	1.10	1.13	1.15	1.18	1.21	1.25	1.27	1.29	17
74	.96	.98	1.00	1.02	1.04	1.05	1.07	1.09	1.11	1.13	1.16	1.19	1.22	1.25	1.27	1.29	16
75	.97	.98	1.00	1.03	1.04	1.06	1.08	1.09	1.12	1.14	1.16	1.19	1.23	1.26	1.28	1.30	15
76	.97	.99	1.00	1.03	1.05	1.06	1.08	1.10	1.12	1.14	1.17	1.20	1.23	1.27	1.29	1.31	14
77	.97	.99	1.01	1.04	1.05	1.07	1.08	1.10	1.13	1.15	1.17	1.20	1.24	1.27	1.29	1.31	13
78	.98	.99	1.01	1.04	1.05	1.07	1.09	1.11	1.13	1.15	1.18	1.21	1.24	1.28	1.30	1.32	12
79	.98	1.00	1.02	1.04	1.06	1.08	1.09	1.11	1.13	1.16	1.18	1.21	1.25	1.28	1.30	1.32	11
80	.98	1.00	1.02	1.05	1.06	1.08	1.10	1.12	1.14	1.16	1.19	1.22	1.25	1.29	1.30	1.33	10
81	.99	1.00	1.02	1.05	1.07	1.08	1.10	1.12	1.14	1.17	1.19	1.22	1.25	1.29	1.31	1.33	9
82	.99	1.01	1.03	1.05	1.07	1.08	1.10	1.12	1.14	1.17	1.19	1.22	1.26	1.29	1.31	1.33	8
83	.99	1.01	1.03	1.06	1.07	1.09	1.10	1.12	1.15	1.17	1.20	1.23	1.26	1.30	1.32	1.34	7
84	.99	1.01	1.03	1.06	1.07	1.09	1.11	1.13	1.15	1.17	1.20	1.23	1.26	1.30	1.32	1.34	6
85	1.00	1.01	1.03	1.06	1.07	1.09	1.11	1.13	1.15	1.17	1.20	1.23	1.26	1.30	1.32	1.34	5
86	1.00	1.01	1.03	1.06	1.08	1.09	1.11	1.13	1.15	1.18	1.20	1.23	1.27	1.30	1.32	1.34	4
87	1.00	1.01	1.03	1.06	1.08	1.09	1.11	1.13	1.15	1.18	1.20	1.23	1.27	1.30	1.32	1.34	3
88	1.00	1.01	1.03	1.06	1.08	1.09	1.11	1.13	1.15	1.18	1.20	1.23	1.27	1.30	1.32	1.34	2
89	1.00	1.02	1.04	1.06	1.08	1.09	1.11	1.13	1.15	1.18	1.21	1.24	1.27	1.31	1.32	1.35	1
90	1.00	1.02	1.04	1.06	1.08	1.09	1.11	1.13	1.15	1.18	1.21	1.24	1.27	1.31	1.32	1.35	0
	0°	10°	15°	20°	22°	24°	26°	28°	30°	32°	34°	36°	38°	40°	41°	42°	

Table B-1. Factors For Star Transit Reduction (A,B,C)-Continued

TOP ARGUMENT=STAR'S DECLINATION, δ

SIDE ARGUMENT=STAR'S ZENITH DISTANCE, ζ

[For factor *A* use left-hand argument. For factor *B* use right-hand argument. Factor *C* is on bottom line of next page]

ζ \ δ	42°	43°	44°	45°	46°	47°	48°	49°	50°	51°	52°	53°	54°	55°	56°	57°	δ / ζ
°																	
1	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	89
2	.05	.05	.05	.05	.05	.05	.05	.05	.05	.06	.06	.06	.06	.06	.06	.06	88
3	.07	.07	.07	.07	.07	.08	.08	.08	.08	.08	.08	.09	.09	.09	.09	.10	87
4	.09	.10	.10	.10	.10	.10	.10	.11	.11	.11	.11	.12	.12	.12	.12	.13	86
5	.12	.12	.12	.12	.13	.13	.13	.13	.13	.14	.14	.14	.15	.15	.16	.16	85
6	.14	.14	.15	.15	.15	.15	.16	.16	.16	.17	.17	.17	.18	.18	.19	.19	84
7	.16	.17	.17	.17	.18	.18	.18	.19	.19	.19	.20	.20	.21	.21	.22	.22	83
8	.19	.19	.19	.20	.20	.20	.21	.21	.22	.22	.23	.23	.24	.24	.25	.26	82
9	.21	.21	.22	.22	.22	.23	.23	.24	.24	.25	.25	.26	.27	.27	.28	.29	81
10	.23	.24	.24	.25	.25	.25	.26	.26	.27	.28	.28	.29	.30	.30	.31	.32	80
11	.26	.26	.27	.27	.28	.28	.28	.29	.30	.30	.31	.32	.32	.33	.34	.35	79
12	.28	.28	.29	.29	.30	.30	.31	.32	.32	.33	.34	.35	.35	.36	.37	.38	78
13	.30	.31	.31	.32	.32	.33	.34	.34	.35	.36	.36	.37	.38	.39	.40	.41	77
14	.33	.33	.34	.34	.35	.35	.36	.37	.38	.38	.39	.40	.41	.42	.43	.44	76
15	.35	.35	.36	.37	.37	.38	.39	.39	.40	.41	.42	.43	.44	.45	.46	.48	75
16	.37	.38	.38	.39	.40	.40	.41	.42	.43	.44	.45	.46	.47	.48	.49	.51	74
17	.39	.40	.41	.41	.42	.43	.44	.45	.45	.46	.47	.49	.50	.51	.52	.54	73
18	.42	.42	.43	.44	.44	.45	.46	.47	.48	.49	.50	.51	.53	.54	.55	.57	72
19	.44	.45	.45	.46	.47	.48	.49	.50	.51	.52	.53	.54	.55	.57	.58	.60	71
20	.46	.47	.48	.48	.49	.50	.51	.52	.53	.54	.56	.57	.58	.60	.61	.63	70
21	.48	.49	.50	.51	.52	.52	.54	.55	.56	.57	.58	.59	.61	.62	.64	.66	69
22	.50	.51	.52	.53	.54	.55	.56	.57	.58	.60	.61	.62	.64	.65	.67	.69	68
23	.53	.53	.54	.55	.56	.57	.58	.60	.61	.62	.63	.65	.66	.68	.70	.72	67
24	.55	.56	.57	.58	.59	.60	.61	.62	.63	.65	.66	.68	.69	.71	.73	.75	66
25	.57	.58	.59	.60	.61	.62	.63	.64	.66	.67	.69	.70	.72	.74	.76	.78	65
26	.59	.60	.61	.62	.63	.64	.65	.67	.68	.70	.71	.73	.75	.76	.78	.80	64
27	.61	.62	.63	.64	.65	.67	.68	.69	.71	.72	.74	.75	.77	.79	.81	.83	63
28	.63	.64	.65	.66	.68	.69	.70	.72	.73	.75	.76	.78	.80	.82	.84	.86	62
29	.65	.66	.67	.69	.70	.71	.72	.74	.75	.77	.79	.81	.82	.84	.87	.89	61
30	.67	.68	.69	.71	.72	.73	.75	.76	.78	.79	.81	.83	.85	.87	.89	.92	60
31	.69	.70	.72	.73	.74	.75	.77	.78	.80	.82	.84	.86	.88	.90	.92	.95	59
32	.71	.72	.74	.75	.76	.78	.79	.81	.82	.84	.86	.88	.90	.92	.95	.97	58
33	.73	.74	.76	.77	.78	.80	.81	.83	.85	.87	.88	.91	.93	.95	.97	1.00	57
34	.75	.76	.78	.79	.80	.82	.84	.85	.87	.89	.91	.93	.95	.97	1.00	1.03	56
35	.77	.78	.80	.81	.83	.84	.86	.87	.89	.91	.93	.95	.98	1.00	1.03	1.05	55
36	.79	.80	.82	.83	.85	.86	.88	.90	.91	.93	.95	.98	1.00	1.03	1.05	1.08	54
37	.81	.82	.84	.85	.87	.88	.90	.92	.94	.96	.98	1.00	1.02	1.05	1.08	1.10	53
38	.83	.84	.86	.87	.89	.90	.92	.94	.96	.98	1.00	1.02	1.05	1.07	1.10	1.13	52
39	.85	.86	.87	.89	.91	.92	.94	.96	.98	1.00	1.02	1.05	1.07	1.10	1.12	1.15	51
40	.86	.88	.89	.91	.93	.94	.96	.98	1.00	1.02	1.04	1.07	1.09	1.12	1.15	1.18	50
41	.88	.90	.91	.93	.94	.96	.98	1.00	1.02	1.04	1.07	1.09	1.12	1.14	1.17	1.20	49
42	.90	.91	.93	.95	.96	.98	1.00	1.02	1.04	1.06	1.09	1.11	1.14	1.17	1.20	1.23	48
43	.92	.93	.95	.96	.98	1.00	1.02	1.04	1.06	1.08	1.11	1.13	1.16	1.19	1.22	1.25	47
44	.93	.95	.97	.98	1.00	1.02	1.04	1.06	1.08	1.10	1.13	1.15	1.18	1.21	1.24	1.28	46
45	.95	.97	.98	1.00	1.02	1.04	1.06	1.08	1.10	1.12	1.15	1.17	1.20	1.23	1.26	1.30	45
	42°	43°	44°	45°	46°	47°	48°	49°	50°	51°	52°	53°	54°	55°	56°	57°	

Table B-1. Factors For Star Transit Reduction (A,B,C)-Continued

TOP ARGUMENT=STAR'S DECLINATION, δ

SIDE ARGUMENT=STAR'S ZENITH DISTANCE, ζ

[For factor *A* use left-hand argument. For factor *B* use right-hand argument. Factor *C* is on line opposite ζ=90°]

ζ \ δ	42°	43°	44°	45°	46°	47°	48°	49°	50°	51°	52°	53°	54°	55°	56°	57°	δ / ζ
°																	°
46	0.97	0.98	1.00	1.02	1.04	1.05	1.07	1.10	1.12	1.14	1.17	1.19	1.22	1.25	1.29	1.32	44
47	.98	1.00	1.02	1.03	1.05	1.07	1.09	1.11	1.14	1.16	1.19	1.21	1.24	1.27	1.31	1.34	43
48	1.00	1.02	1.03	1.05	1.07	1.09	1.11	1.13	1.16	1.18	1.21	1.23	1.26	1.30	1.33	1.36	42
49	1.02	1.03	1.05	1.07	1.09	1.11	1.13	1.15	1.17	1.20	1.23	1.25	1.28	1.32	1.35	1.39	41
50	1.03	1.05	1.06	1.08	1.10	1.12	1.14	1.17	1.19	1.22	1.24	1.27	1.30	1.34	1.37	1.41	40
51	1.05	1.06	1.08	1.10	1.12	1.14	1.16	1.18	1.21	1.23	1.26	1.29	1.32	1.35	1.39	1.43	39
52	1.06	1.08	1.10	1.11	1.13	1.15	1.18	1.20	1.23	1.25	1.28	1.31	1.34	1.37	1.41	1.45	38
53	1.07	1.09	1.11	1.13	1.15	1.17	1.19	1.22	1.24	1.27	1.30	1.33	1.36	1.39	1.43	1.47	37
54	1.09	1.11	1.12	1.14	1.16	1.19	1.21	1.23	1.26	1.29	1.31	1.34	1.38	1.41	1.45	1.49	36
55	1.10	1.12	1.14	1.16	1.18	1.20	1.22	1.25	1.27	1.30	1.33	1.36	1.39	1.43	1.46	1.50	35
56	1.12	1.13	1.15	1.17	1.19	1.22	1.24	1.26	1.29	1.32	1.35	1.38	1.41	1.45	1.48	1.52	34
57	1.13	1.15	1.17	1.19	1.21	1.23	1.25	1.28	1.31	1.33	1.36	1.39	1.43	1.46	1.50	1.54	33
58	1.14	1.16	1.18	1.20	1.22	1.24	1.27	1.29	1.32	1.35	1.38	1.41	1.44	1.48	1.52	1.56	32
59	1.15	1.17	1.19	1.21	1.23	1.26	1.28	1.31	1.33	1.36	1.39	1.42	1.46	1.49	1.53	1.57	31
60	1.17	1.18	1.20	1.22	1.25	1.27	1.29	1.32	1.35	1.38	1.41	1.44	1.47	1.51	1.55	1.59	30
61	1.18	1.20	1.22	1.24	1.26	1.28	1.31	1.33	1.36	1.39	1.42	1.45	1.49	1.53	1.56	1.61	29
62	1.19	1.21	1.23	1.25	1.27	1.29	1.32	1.35	1.37	1.40	1.43	1.47	1.50	1.54	1.58	1.62	28
63	1.20	1.22	1.24	1.26	1.28	1.31	1.33	1.36	1.39	1.42	1.45	1.48	1.52	1.55	1.59	1.64	27
64	1.21	1.23	1.25	1.27	1.29	1.32	1.34	1.37	1.40	1.43	1.46	1.49	1.53	1.57	1.61	1.65	26
65	1.22	1.24	1.26	1.28	1.30	1.33	1.35	1.38	1.41	1.44	1.47	1.51	1.54	1.58	1.62	1.66	25
66	1.23	1.25	1.27	1.29	1.32	1.34	1.37	1.39	1.42	1.45	1.48	1.52	1.55	1.59	1.63	1.68	24
67	1.24	1.26	1.28	1.30	1.33	1.35	1.38	1.40	1.43	1.46	1.50	1.53	1.57	1.60	1.65	1.69	23
68	1.25	1.27	1.29	1.31	1.33	1.36	1.39	1.41	1.44	1.47	1.51	1.54	1.58	1.62	1.66	1.70	22
69	1.26	1.28	1.30	1.32	1.34	1.37	1.40	1.42	1.45	1.48	1.52	1.55	1.59	1.63	1.67	1.71	21
70	1.26	1.28	1.31	1.33	1.35	1.38	1.40	1.43	1.46	1.49	1.53	1.56	1.60	1.64	1.68	1.73	20
71	1.27	1.29	1.31	1.34	1.36	1.39	1.41	1.44	1.47	1.50	1.54	1.57	1.61	1.65	1.69	1.74	19
72	1.28	1.30	1.32	1.34	1.37	1.39	1.42	1.45	1.48	1.51	1.54	1.58	1.62	1.66	1.70	1.75	18
73	1.29	1.31	1.33	1.35	1.38	1.40	1.43	1.46	1.49	1.52	1.55	1.59	1.63	1.67	1.71	1.76	17
74	1.29	1.31	1.34	1.36	1.38	1.41	1.44	1.46	1.49	1.53	1.56	1.60	1.63	1.68	1.72	1.76	16
75	1.30	1.32	1.34	1.37	1.39	1.42	1.44	1.47	1.50	1.53	1.57	1.60	1.64	1.68	1.73	1.77	15
76	1.31	1.33	1.35	1.37	1.40	1.42	1.45	1.48	1.51	1.54	1.58	1.61	1.65	1.69	1.73	1.78	14
77	1.31	1.33	1.35	1.38	1.40	1.43	1.46	1.48	1.52	1.55	1.58	1.62	1.66	1.70	1.74	1.79	13
78	1.32	1.34	1.36	1.38	1.41	1.43	1.46	1.49	1.52	1.55	1.59	1.62	1.66	1.70	1.75	1.80	12
79	1.32	1.34	1.36	1.39	1.41	1.44	1.47	1.50	1.53	1.56	1.59	1.63	1.67	1.71	1.76	1.80	11
80	1.33	1.35	1.37	1.39	1.42	1.44	1.47	1.50	1.53	1.56	1.60	1.64	1.67	1.72	1.76	1.81	10
81	1.33	1.35	1.37	1.40	1.42	1.45	1.48	1.51	1.54	1.57	1.60	1.64	1.68	1.72	1.77	1.81	9
82	1.33	1.35	1.38	1.40	1.43	1.45	1.48	1.51	1.54	1.57	1.61	1.64	1.68	1.73	1.77	1.82	8
83	1.34	1.36	1.38	1.40	1.43	1.46	1.48	1.51	1.54	1.58	1.61	1.65	1.69	1.73	1.77	1.82	7
84	1.34	1.36	1.38	1.41	1.43	1.46	1.49	1.52	1.55	1.58	1.62	1.65	1.69	1.73	1.78	1.83	6
85	1.34	1.36	1.38	1.41	1.43	1.46	1.49	1.52	1.55	1.58	1.62	1.65	1.69	1.74	1.78	1.83	5
86	1.34	1.36	1.39	1.41	1.44	1.46	1.49	1.52	1.55	1.59	1.62	1.66	1.70	1.74	1.78	1.83	4
87	1.34	1.37	1.39	1.41	1.44	1.46	1.49	1.52	1.55	1.59	1.62	1.66	1.70	1.74	1.79	1.83	3
88	1.34	1.37	1.39	1.41	1.44	1.46	1.49	1.52	1.55	1.59	1.62	1.66	1.70	1.74	1.79	1.83	2
89	1.35	1.37	1.39	1.41	1.44	1.47	1.49	1.52	1.56	1.59	1.62	1.66	1.70	1.74	1.79	1.84	1
90	1.35	1.37	1.39	1.41	1.44	1.47	1.49	1.52	1.56	1.59	1.62	1.66	1.70	1.74	1.79	1.84	0
	42°	43°	44°	45°	46°	47°	48°	49°	50°	51°	52°	53°	54°	55°	56°	57°	

Table B-1. Factors For Star Transit Reduction (A,B,C)-Continued

TOP ARGUMENT=STAR'S DECLINATION, δ

SIDE ARGUMENT=STAR'S ZENITH DISTANCE, ζ

[For factor *A* use left-hand argument. For factor *B* use right-hand argument. Factor *C* is on bottom line of next page]

δ \ ζ	57°	58°	58½°	59°	59½°	60°	60½°	61°	61½°	62°	62½°	63°	63½°	64°	64½°	65°	δ / ζ
°																	°
1	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	89
2	.06	.07	.07	.07	.07	.07	.07	.07	.07	.07	.08	.08	.08	.08	.08	.08	88
3	.10	.10	.10	.10	.10	.10	.11	.11	.11	.11	.11	.12	.12	.12	.12	.12	87
4	.13	.13	.13	.14	.14	.14	.14	.14	.15	.15	.15	.15	.16	.16	.16	.17	86
5	.16	.16	.17	.17	.17	.17	.18	.18	.18	.19	.19	.19	.19	.20	.20	.21	85
6	.19	.20	.20	.20	.21	.21	.21	.22	.22	.22	.23	.23	.23	.24	.24	.25	84
7	.22	.23	.23	.24	.24	.24	.25	.25	.26	.26	.26	.27	.27	.28	.28	.29	83
8	.26	.26	.27	.27	.27	.28	.28	.29	.29	.30	.30	.31	.31	.32	.32	.33	82
9	.29	.29	.30	.30	.31	.31	.32	.32	.33	.33	.34	.35	.35	.36	.36	.37	81
10	.32	.33	.33	.34	.34	.35	.35	.36	.36	.37	.38	.38	.39	.40	.40	.41	80
11	.35	.36	.36	.37	.38	.38	.39	.39	.40	.41	.41	.42	.43	.44	.44	.45	79
12	.38	.39	.40	.40	.41	.42	.42	.43	.44	.44	.45	.46	.47	.47	.48	.49	78
13	.41	.42	.43	.44	.44	.45	.46	.46	.47	.48	.49	.50	.50	.51	.52	.53	77
14	.44	.46	.46	.47	.48	.48	.49	.50	.51	.52	.52	.53	.54	.55	.56	.57	76
15	.48	.49	.50	.50	.51	.52	.53	.53	.54	.55	.56	.57	.58	.59	.60	.61	75
16	.51	.52	.53	.54	.54	.55	.56	.57	.58	.59	.60	.61	.62	.63	.64	.65	74
17	.54	.55	.56	.57	.58	.58	.59	.60	.61	.62	.63	.64	.66	.67	.68	.69	73
18	.57	.58	.59	.60	.61	.62	.63	.64	.65	.66	.67	.68	.69	.70	.72	.73	72
19	.60	.61	.62	.63	.64	.65	.66	.67	.68	.69	.70	.72	.73	.74	.76	.77	71
20	.63	.64	.65	.66	.67	.68	.69	.70	.72	.73	.74	.75	.77	.78	.79	.81	70
21	.66	.68	.69	.70	.71	.72	.73	.74	.75	.76	.78	.79	.80	.82	.83	.85	69
22	.69	.71	.72	.73	.74	.75	.76	.77	.78	.80	.81	.82	.84	.85	.87	.89	68
23	.72	.74	.75	.76	.77	.78	.79	.81	.82	.83	.85	.86	.88	.89	.91	.92	67
24	.75	.77	.78	.79	.80	.81	.83	.84	.85	.87	.88	.90	.91	.93	.94	.96	66
25	.78	.80	.81	.82	.83	.85	.86	.87	.89	.90	.92	.93	.95	.96	.98	1.00	65
26	.80	.83	.84	.85	.86	.88	.89	.90	.92	.93	.95	.97	.98	1.00	1.02	1.04	64
27	.83	.86	.87	.88	.89	.91	.92	.94	.95	.97	.98	1.00	1.02	1.04	1.05	1.07	63
28	.86	.89	.90	.91	.93	.94	.95	.97	.98	1.00	1.02	1.03	1.05	1.07	1.09	1.11	62
29	.89	.91	.93	.94	.96	.97	.98	1.00	1.02	1.03	1.05	1.07	1.09	1.11	1.13	1.15	61
30	.92	.94	.96	.97	.99	1.00	1.01	1.03	1.05	1.07	1.08	1.10	1.12	1.14	1.16	1.18	60
31	.95	.97	.99	1.00	1.01	1.03	1.05	1.06	1.08	1.10	1.11	1.13	1.15	1.17	1.20	1.22	59
32	.97	1.00	1.01	1.03	1.04	1.06	1.08	1.09	1.11	1.13	1.15	1.17	1.19	1.21	1.23	1.25	58
33	1.00	1.03	1.04	1.06	1.07	1.09	1.11	1.12	1.14	1.16	1.18	1.20	1.22	1.24	1.26	1.29	57
34	1.03	1.05	1.07	1.09	1.10	1.12	1.14	1.15	1.17	1.19	1.21	1.23	1.25	1.27	1.30	1.32	56
35	1.05	1.08	1.10	1.11	1.13	1.15	1.16	1.18	1.20	1.22	1.24	1.26	1.29	1.31	1.33	1.36	55
36	1.08	1.11	1.12	1.14	1.16	1.18	1.19	1.21	1.23	1.25	1.27	1.30	1.32	1.34	1.37	1.39	54
37	1.10	1.14	1.15	1.17	1.19	1.20	1.22	1.24	1.26	1.28	1.30	1.33	1.35	1.37	1.40	1.42	53
38	1.13	1.16	1.18	1.20	1.21	1.23	1.25	1.27	1.29	1.31	1.33	1.36	1.38	1.40	1.43	1.46	52
39	1.15	1.19	1.20	1.22	1.24	1.26	1.28	1.30	1.32	1.34	1.36	1.39	1.41	1.43	1.46	1.49	51
40	1.18	1.21	1.23	1.25	1.27	1.29	1.31	1.33	1.35	1.37	1.39	1.42	1.44	1.47	1.49	1.52	50
41	1.20	1.24	1.26	1.27	1.29	1.31	1.33	1.35	1.37	1.40	1.42	1.45	1.47	1.50	1.52	1.55	49
42	1.23	1.26	1.28	1.30	1.32	1.34	1.36	1.38	1.40	1.42	1.45	1.47	1.50	1.53	1.55	1.58	48
43	1.25	1.29	1.30	1.32	1.34	1.36	1.39	1.41	1.43	1.45	1.48	1.50	1.53	1.56	1.58	1.61	47
44	1.28	1.31	1.33	1.35	1.37	1.39	1.41	1.43	1.46	1.48	1.50	1.53	1.56	1.58	1.61	1.64	46
45	1.30	1.33	1.35	1.37	1.39	1.41	1.44	1.46	1.48	1.51	1.53	1.56	1.58	1.61	1.64	1.67	45
	57°	58°	58½°	59°	59½°	60°	60½°	61°	61½°	62°	62½°	63°	63½°	64°	64½°	65°	

Table B-1. Factors For Star Transit Reduction (A,B,C)-Continued

TOP ARGUMENT=STAR'S DECLINATION, δ

SIDE ARGUMENT=STAR'S ZENITH DISTANCE, ζ

[For factor *A* use left-hand argument. For factor *B* use right-hand argument. Factor *C* is on line opposite ζ=90°]

ζ \ δ	57°	58°	58½°	59°	59½°	60°	60½°	61°	61½°	62°	62½°	63°	63½°	64°	64½°	65°	δ / ζ
°																	°
46	1.32	1.36	1.38	1.40	1.42	1.44	1.46	1.48	1.51	1.53	1.56	1.58	1.61	1.64	1.67	1.70	44
47	1.34	1.38	1.40	1.42	1.44	1.46	1.49	1.51	1.53	1.56	1.58	1.61	1.64	1.67	1.70	1.73	43
48	1.36	1.40	1.42	1.44	1.46	1.48	1.51	1.53	1.55	1.58	1.60	1.63	1.66	1.69	1.72	1.76	42
49	1.39	1.42	1.44	1.47	1.49	1.51	1.53	1.56	1.58	1.61	1.63	1.66	1.69	1.72	1.75	1.79	41
50	1.41	1.44	1.47	1.49	1.51	1.53	1.56	1.58	1.60	1.63	1.66	1.69	1.72	1.75	1.78	1.81	40
51	1.43	1.47	1.49	1.51	1.53	1.55	1.58	1.60	1.63	1.66	1.68	1.71	1.74	1.77	1.80	1.84	39
52	1.45	1.49	1.51	1.53	1.55	1.58	1.60	1.63	1.65	1.68	1.71	1.74	1.77	1.80	1.83	1.86	38
53	1.47	1.51	1.53	1.55	1.57	1.60	1.62	1.65	1.67	1.70	1.73	1.76	1.79	1.82	1.85	1.89	37
54	1.49	1.53	1.55	1.57	1.59	1.62	1.64	1.67	1.69	1.72	1.75	1.78	1.81	1.85	1.88	1.91	36
55	1.50	1.55	1.57	1.59	1.61	1.64	1.66	1.69	1.72	1.74	1.77	1.80	1.84	1.87	1.90	1.94	35
56	1.52	1.56	1.59	1.61	1.63	1.66	1.68	1.71	1.74	1.77	1.80	1.83	1.86	1.89	1.93	1.96	34
57	1.54	1.58	1.61	1.63	1.65	1.68	1.70	1.73	1.76	1.79	1.82	1.85	1.88	1.91	1.95	1.98	33
58	1.56	1.60	1.62	1.65	1.67	1.70	1.72	1.75	1.78	1.81	1.84	1.87	1.90	1.93	1.97	2.01	32
59	1.57	1.62	1.64	1.66	1.69	1.71	1.74	1.77	1.80	1.83	1.86	1.89	1.92	1.96	1.99	2.03	31
60	1.59	1.63	1.66	1.68	1.71	1.73	1.76	1.79	1.81	1.84	1.88	1.91	1.94	1.98	2.01	2.05	30
61	1.61	1.65	1.67	1.70	1.72	1.75	1.78	1.80	1.83	1.86	1.89	1.93	1.96	2.00	2.03	2.07	29
62	1.62	1.67	1.69	1.71	1.74	1.77	1.79	1.82	1.85	1.88	1.91	1.94	1.98	2.01	2.05	2.09	28
63	1.64	1.68	1.70	1.73	1.76	1.78	1.81	1.84	1.87	1.90	1.93	1.96	2.00	2.03	2.07	2.11	27
64	1.65	1.70	1.72	1.75	1.77	1.80	1.83	1.85	1.88	1.91	1.95	1.98	2.02	2.05	2.09	2.13	26
65	1.66	1.71	1.73	1.76	1.79	1.81	1.84	1.87	1.90	1.93	1.96	2.00	2.03	2.07	2.11	2.14	25
66	1.68	1.72	1.75	1.77	1.80	1.83	1.85	1.88	1.91	1.95	1.98	2.01	2.05	2.08	2.12	2.16	24
67	1.69	1.74	1.76	1.79	1.81	1.84	1.87	1.90	1.93	1.96	1.99	2.03	2.06	2.10	2.14	2.18	23
68	1.70	1.75	1.77	1.80	1.83	1.85	1.88	1.91	1.94	1.97	2.01	2.04	2.08	2.11	2.15	2.19	22
69	1.71	1.76	1.79	1.81	1.84	1.87	1.90	1.93	1.96	1.99	2.02	2.06	2.09	2.13	2.17	2.21	21
70	1.73	1.77	1.80	1.82	1.85	1.88	1.91	1.94	1.97	2.00	2.03	2.07	2.11	2.14	2.18	2.22	20
71	1.74	1.78	1.81	1.84	1.86	1.89	1.92	1.95	1.98	2.01	2.05	2.08	2.12	2.16	2.20	2.24	19
72	1.75	1.79	1.82	1.85	1.87	1.90	1.93	1.96	1.99	2.03	2.06	2.09	2.13	2.17	2.21	2.25	18
73	1.76	1.80	1.83	1.86	1.88	1.91	1.94	1.97	2.00	2.04	2.07	2.11	2.14	2.18	2.22	2.26	17
74	1.76	1.81	1.84	1.87	1.89	1.92	1.95	1.98	2.01	2.05	2.08	2.12	2.15	2.19	2.23	2.27	16
75	1.77	1.82	1.85	1.88	1.90	1.93	1.96	1.99	2.02	2.06	2.09	2.13	2.16	2.20	2.24	2.29	15
76	1.78	1.83	1.86	1.88	1.91	1.94	1.97	2.00	2.03	2.07	2.10	2.14	2.17	2.21	2.25	2.30	14
77	1.79	1.84	1.86	1.89	1.92	1.95	1.98	2.01	2.04	2.07	2.11	2.15	2.18	2.22	2.26	2.31	13
78	1.80	1.85	1.87	1.90	1.93	1.96	1.99	2.02	2.05	2.08	2.12	2.15	2.19	2.23	2.27	2.31	12
79	1.80	1.85	1.88	1.91	1.93	1.96	1.99	2.02	2.06	2.09	2.13	2.16	2.20	2.24	2.28	2.32	11
80	1.81	1.86	1.88	1.91	1.94	1.97	2.00	2.03	2.06	2.10	2.13	2.17	2.21	2.25	2.29	2.33	10
81	1.81	1.86	1.89	1.92	1.95	1.98	2.01	2.04	2.07	2.10	2.14	2.18	2.21	2.25	2.29	2.34	9
82	1.82	1.87	1.90	1.92	1.95	1.98	2.01	2.04	2.08	2.11	2.15	2.18	2.22	2.26	2.30	2.34	8
83	1.82	1.87	1.90	1.93	1.96	1.99	2.02	2.05	2.08	2.12	2.15	2.19	2.22	2.26	2.31	2.35	7
84	1.83	1.88	1.90	1.93	1.96	1.99	2.02	2.05	2.08	2.12	2.15	2.19	2.23	2.27	2.31	2.35	6
85	1.83	1.88	1.91	1.93	1.96	1.99	2.02	2.05	2.09	2.12	2.16	2.19	2.23	2.27	2.31	2.36	5
86	1.83	1.88	1.91	1.94	1.97	2.00	2.03	2.06	2.09	2.13	2.16	2.20	2.24	2.28	2.32	2.36	4
87	1.83	1.88	1.91	1.94	1.97	2.00	2.03	2.06	2.09	2.13	2.16	2.20	2.24	2.28	2.32	2.36	3
88	1.83	1.89	1.91	1.94	1.97	2.00	2.03	2.06	2.09	2.13	2.16	2.20	2.24	2.28	2.32	2.36	2
89	1.84	1.89	1.91	1.94	1.97	2.00	2.03	2.06	2.10	2.13	2.17	2.20	2.24	2.28	2.32	2.37	1
90	1.84	1.89	1.91	1.94	1.97	2.00	2.03	2.06	2.10	2.13	2.17	2.20	2.24	2.28	2.32	2.37	0
	57°	58°	58½°	59°	59½°	60°	60½°	61°	61½°	62°	62½°	63°	63½°	64°	64½°	65°	

Table B-1. Factors For Star Transit Reduction (A,B,C)-Continued

TOP ARGUMENT=STAR'S DECLINATION, δ

SIDE ARGUMENT=STAR'S ZENITH DISTANCE, ζ

[For factor *A* use left-hand argument. For factor *B* use right-hand argument. Factor *C* is on bottom line of next page]

δ ζ	65°	65½°	66°	66½°	67°	67½°	68°	68½°	69°	69° 10′	69° 20′	69° 30′	69° 40′	69° 50′	70°	70° 10′	δ ζ
°																	°
1	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	89
2	.08	.08	.09	.09	.09	.09	.09	.10	.10	.10	.10	.10	.10	.10	.10	.10	88
3	.12	.13	.13	.13	.13	.14	.14	.14	.15	.15	.15	.15	.15	.15	.15	.15	87
4	.17	.17	.17	.18	.18	.18	.19	.19	.20	.20	.20	.20	.20	.20	.20	.20	86
5	.21	.21	.21	.22	.22	.23	.23	.24	.24	.24	.25	.25	.25	.25	.25	.26	85
6	.25	.25	.26	.26	.27	.27	.28	.28	.29	.29	.30	.30	.30	.30	.31	.31	84
7	.29	.29	.30	.31	.31	.32	.33	.33	.34	.34	.34	.35	.35	.35	.36	.36	83
8	.33	.34	.34	.35	.36	.36	.37	.38	.39	.39	.39	.40	.40	.40	.41	.41	82
9	.37	.38	.39	.39	.40	.41	.42	.43	.44	.44	.44	.45	.45	.45	.46	.46	81
10	.41	.42	.43	.43	.44	.45	.46	.47	.48	.49	.49	.50	.50	.50	.51	.51	80
11	.45	.46	.47	.48	.49	.50	.51	.52	.53	.54	.54	.54	.55	.55	.56	.56	79
12	.49	.50	.51	.52	.53	.54	.56	.57	.58	.58	.59	.59	.60	.60	.61	.61	78
13	.53	.54	.55	.56	.58	.59	.60	.61	.63	.63	.64	.64	.65	.65	.66	.66	77
14	.57	.58	.59	.61	.62	.63	.65	.66	.67	.68	.68	.69	.70	.70	.71	.71	76
15	.61	.62	.64	.65	.66	.68	.69	.71	.72	.73	.73	.74	.74	.75	.76	.76	75
16	.65	.66	.68	.69	.71	.72	.74	.75	.77	.78	.78	.79	.79	.80	.81	.81	74
17	.69	.70	.72	.73	.75	.76	.78	.80	.81	.82	.83	.83	.84	.85	.85	.86	73
18	.73	.74	.76	.77	.79	.81	.83	.84	.86	.87	.88	.88	.89	.90	.90	.91	72
19	.77	.78	.80	.82	.83	.85	.87	.89	.91	.92	.92	.93	.94	.94	.95	.96	71
20	.81	.82	.84	.86	.88	.89	.91	.93	.95	.96	.97	.98	.98	.99	1.00	1.01	70
21	.85	.86	.88	.90	.92	.94	.96	.98	1.00	1.01	1.02	1.02	1.03	1.04	1.05	1.06	69
22	.89	.90	.92	.94	.96	.98	1.00	1.02	1.05	1.05	1.06	1.07	1.08	1.09	1.09	1.10	68
23	.92	.94	.96	.98	1.00	1.02	1.04	1.07	1.09	1.10	1.11	1.12	1.12	1.13	1.14	1.15	67
24	.96	.98	1.00	1.02	1.04	1.06	1.09	1.11	1.14	1.14	1.15	1.16	1.17	1.18	1.19	1.20	66
25	1.00	1.02	1.04	1.06	1.08	1.10	1.13	1.15	1.18	1.19	1.20	1.21	1.22	1.23	1.24	1.25	65
26	1.04	1.06	1.08	1.10	1.12	1.15	1.17	1.20	1.22	1.23	1.24	1.25	1.26	1.27	1.28	1.29	64
27	1.07	1.09	1.12	1.14	1.16	1.19	1.21	1.24	1.27	1.28	1.29	1.30	1.31	1.32	1.33	1.34	63
28	1.11	1.13	1.15	1.18	1.20	1.23	1.25	1.28	1.31	1.32	1.33	1.34	1.35	1.36	1.37	1.38	62
29	1.15	1.17	1.19	1.22	1.24	1.27	1.29	1.32	1.35	1.36	1.37	1.38	1.40	1.41	1.42	1.43	61
30	1.18	1.21	1.23	1.25	1.28	1.31	1.33	1.36	1.39	1.41	1.42	1.43	1.44	1.45	1.46	1.47	60
31	1.22	1.24	1.27	1.29	1.32	1.35	1.38	1.40	1.44	1.45	1.46	1.47	1.48	1.49	1.51	1.52	59
32	1.25	1.28	1.30	1.33	1.36	1.39	1.42	1.45	1.48	1.49	1.50	1.51	1.52	1.54	1.55	1.56	58
33	1.29	1.31	1.34	1.37	1.39	1.42	1.45	1.49	1.52	1.53	1.54	1.55	1.57	1.58	1.59	1.60	57
34	1.32	1.35	1.37	1.40	1.43	1.46	1.49	1.53	1.56	1.57	1.58	1.60	1.61	1.62	1.63	1.65	56
35	1.36	1.38	1.41	1.44	1.47	1.50	1.53	1.56	1.60	1.61	1.62	1.64	1.65	1.66	1.68	1.69	55
36	1.39	1.42	1.45	1.47	1.51	1.54	1.57	1.60	1.64	1.65	1.66	1.68	1.69	1.70	1.72	1.73	54
37	1.42	1.45	1.48	1.51	1.54	1.57	1.61	1.64	1.68	1.69	1.70	1.72	1.73	1.74	1.76	1.77	53
38	1.46	1.48	1.51	1.54	1.58	1.61	1.64	1.68	1.72	1.73	1.74	1.76	1.77	1.79	1.80	1.82	52
39	1.49	1.52	1.55	1.58	1.61	1.65	1.68	1.72	1.75	1.77	1.78	1.80	1.81	1.82	1.84	1.86	51
40	1.52	1.55	1.58	1.61	1.65	1.68	1.72	1.75	1.79	1.81	1.82	1.84	1.85	1.86	1.88	1.89	50
41	1.55	1.58	1.61	1.64	1.68	1.71	1.75	1.79	1.83	1.84	1.86	1.87	1.89	1.90	1.92	1.93	49
42	1.58	1.61	1.64	1.68	1.71	1.75	1.79	1.83	1.87	1.88	1.90	1.91	1.93	1.94	1.96	1.97	48
43	1.61	1.64	1.68	1.71	1.75	1.78	1.82	1.86	1.90	1.92	1.93	1.95	1.96	1.98	1.99	2.01	47
44	1.64	1.67	1.71	1.74	1.78	1.82	1.85	1.90	1.94	1.95	1.97	1.98	2.00	2.02	2.03	2.05	46
45	1.67	1.70	1.74	1.77	1.81	1.85	1.89	1.93	1.97	1.99	2.00	2.02	2.04	2.05	2.07	2.08	45
	65°	65½°	66°	66½°	67°	67½°	68°	68½°	69°	69° 10′	69° 20′	69° 30′	69° 40′	69° 50′	70°	70° 10′	

Table B-1. Factors For Star Transit Reduction (A,B,C)-Continued

TOP ARGUMENT=STAR'S DECLINATION, δ

SIDE ARGUMENT=STAR'S ZENITH DISTANCE, ζ

[For factor *A* use left-hand argument. For factor *B* use right-hand argument. Factor *C* is on line opposite ζ=90°]

ζ \ δ	65°	65½°	66°	66½°	67°	67½°	68°	68½°	69°	69° 10′	69° 20′	69° 30′	69° 40′	69° 50′	70°	70° 10′	δ / ζ
°																	°
46	1.70	1.74	1.77	1.80	1.84	1.88	1.92	1.96	2.01	2.02	2.04	2.05	2.07	2.09	2.10	2.12	44
47	1.73	1.76	1.80	1.83	1.87	1.91	1.95	2.00	2.04	2.06	2.07	2.09	2.10	2.12	2.14	2.16	43
48	1.76	1.79	1.83	1.86	1.90	1.94	1.98	2.03	2.07	2.09	2.11	2.12	2.14	2.16	2.17	2.19	42
49	1.79	1.82	1.86	1.89	1.93	1.97	2.01	2.06	2.11	2.12	2.14	2.16	2.17	2.19	2.21	2.22	41
50	1.81	1.85	1.88	1.92	1.96	2.00	2.04	2.09	2.14	2.15	2.17	2.19	2.20	2.22	2.24	2.26	40
51	1.84	1.87	1.91	1.95	1.99	2.03	2.07	2.12	2.17	2.18	2.20	2.22	2.24	2.25	2.27	2.29	39
52	1.86	1.90	1.94	1.98	2.02	2.06	2.10	2.15	2.20	2.22	2.23	2.25	2.27	2.29	2.30	2.32	38
53	1.89	1.93	1.96	2.00	2.04	2.09	2.13	2.18	2.23	2.25	2.26	2.28	2.30	2.32	2.33	2.35	37
54	1.91	1.95	1.99	2.03	2.07	2.11	2.16	2.21	2.26	2.28	2.29	2.31	2.33	2.35	2.37	2.38	36
55	1.94	1.98	2.01	2.05	2.10	2.14	2.19	2.23	2.29	2.30	2.32	2.34	2.36	2.38	2.40	2.41	35
56	1.96	2.00	2.04	2.08	2.12	2.17	2.21	2.26	2.31	2.33	2.35	2.37	2.39	2.40	2.42	2.44	34
57	1.98	2.02	2.06	2.10	2.15	2.19	2.24	2.29	2.34	2.36	2.38	2.39	2.41	2.43	2.45	2.47	33
58	2.01	2.05	2.08	2.13	2.17	2.22	2.26	2.31	2.37	2.38	2.40	2.42	2.44	2.46	2.48	2.50	32
59	2.03	2.07	2.11	2.15	2.19	2.24	2.29	2.34	2.39	2.41	2.43	2.45	2.47	2.49	2.51	2.53	31
60	2.05	2.09	2.13	2.17	2.22	2.26	2.31	2.36	2.42	2.44	2.45	2.47	2.49	2.51	2.53	2.55	30
61	2.07	2.11	2.15	2.19	2.24	2.29	2.33	2.39	2.44	2.46	2.48	2.50	2.52	2.54	2.56	2.58	29
62	2.09	2.13	2.17	2.21	2.26	2.31	2.36	2.41	2.46	2.48	2.50	2.52	2.54	2.56	2.58	2.60	28
63	2.11	2.15	2.19	2.23	2.28	2.33	2.38	2.43	2.49	2.50	2.52	2.54	2.56	2.58	2.60	2.63	27
64	2.13	2.17	2.21	2.25	2.30	2.35	2.40	2.45	2.51	2.53	2.55	2.57	2.59	2.61	2.63	2.65	26
65	2.14	2.19	2.23	2.27	2.32	2.37	2.42	2.47	2.53	2.55	2.57	2.59	2.61	2.63	2.65	2.67	25
66	2.16	2.20	2.25	2.29	2.34	2.39	2.44	2.49	2.55	2.57	2.59	2.61	2.63	2.65	2.67	2.69	24
67	2.18	2.22	2.26	2.31	2.36	2.41	2.46	2.51	2.57	2.59	2.61	2.63	2.65	2.67	2.69	2.71	23
68	2.19	2.24	2.28	2.32	2.37	2.42	2.47	2.53	2.59	2.61	2.63	2.65	2.67	2.69	2.71	2.73	22
69	2.21	2.25	2.30	2.34	2.39	2.44	2.49	2.55	2.61	2.62	2.64	2.67	2.69	2.71	2.73	2.75	21
70	2.22	2.27	2.31	2.36	2.40	2.46	2.51	2.56	2.62	2.64	2.66	2.68	2.70	2.73	2.75	2.77	20
71	2.24	2.28	2.32	2.37	2.42	2.47	2.52	2.58	2.64	2.66	2.68	2.70	2.72	2.74	2.77	2.79	19
72	2.25	2.29	2.34	2.38	2.43	2.49	2.54	2.59	2.65	2.67	2.70	2.72	2.74	2.76	2.78	2.80	18
73	2.26	2.31	2.35	2.40	2.45	2.50	2.55	2.61	2.67	2.69	2.71	2.73	2.75	2.77	2.80	2.82	17
74	2.27	2.32	2.36	2.41	2.46	2.51	2.57	2.62	2.68	2.70	2.72	2.74	2.77	2.79	2.81	2.83	16
75	2.29	2.33	2.37.	2.42	2.47	2.52	2.58	2.64	2.70	2.72	2.74	2.76	2.78	2.80	2.82	2.85	15
76	2.30	2.34	2.39	2.43	2.48	2.54	2.59	2.65	2.71	2.73	2.75	2.77	2.79	2.81	2.84	2.86	14
77	2.31	2.35	2.40	2.44	2.49	2.55	2.60	2.66	2.72	2.74	2.76	2.78	2.80	2.83	2.85	2.87	13
78	2.31	2.36	2.40	2.45	2.50	2.56	2.61	2.67	2.73	2.75	2.77	2.79	2.81	2.84	2.86	2.88	12
79	2.32	2.37	2.41	2.46	2.51	2.57	2.62	2.68	2.74	2.76	2.78	2.80	2.82	2.85	2.87	2.89	11
80	2.33	2.38	2.42	2.47	2.52	2.57	2.63	2.69	2.75	2.77	2.79	2.81	2.83	2.86	2.88	2.90	10
81	2.34	2.38	2.43	2.48	2.53	2.58	2.64	2.69	2.76	2.78	2.80	2.82	2.84	2.86	2.89	2.91	9
82	2.34	2.39	2.43	2.48	2.53	2.59	2.64	2.70	2.76	2.78	2.81	2.83	2.85	2.87	2.90	2.92	8
83	2.35	2.39	2.44	2.49	2.54	2.59	2.65	2.71	2.77	2.79	2.81	2.83	2.86	2.88	2.90	2.92	7
84	2.35	2.40	2.45	2.49	2.55	2.60	2.66	2.71	2.78	2.80	2.82	2.84	2.86	2.88	2.91	2.93	6
85	2.36	2.40	2.45	2.50	2.55	2.60	2.66	2.72	2.78	2.80	2.82	2.84	2.87	2.89	2.91	2.94	5
86	2.36	2.41	2.45	2.50	2.55	2.61	2.66	2.72	2.78	2.80	2.83	2.85	2.87	2.89	2.92	2.94	4
87	2.36	2.41	2.46	2.50	2.56	2.61	2.67	2.72	2.79	2.81	2.83	2.85	2.87	2.90	2.92	2.94	3
88	2.36	2.41	2.46	2.51	2.56	2.61	2.67	2.73	2.79	2.81	2.83	2.85	2.88	2.90	2.92	2.95	2
89	2.37	2.41	2.46	2.51	2.56	2.61	2.67	2.73	2.79	2.81	2.83	2.86	2.88	2.90	2.92	2.95	1
90	2.37	2.41	2.46	2.51	2.56	2.61	2.67	2.73	2.79	2.81	2.83	2.86	2.88	2.90	2.92	2.95	0
	65°	65½°	66°	66½°	67°	67½°	68°	68½°	69°	69° 10′	69° 20′	69° 30′	69° 40′	69° 50′	70°	70° 10′	

Table B-1. Factors For Star Transit Reduction (A,B,C)-Continued

TOP ARGUMENT=STAR'S DECLINATION, δ

SIDE ARGUMENT=STAR'S ZENITH DISTANCE, ζ

[For factor *A* use left-hand argument. For factor *B* use right-hand argument. Factor *C* is on bottom line of next page]

ζ \ δ	70° 10′	70° 20′	70° 30′	70° 40′	70° 50′	71°	71° 10′	71° 20′	71° 30′	71° 40′	71° 50′	72°	72° 10′	72° 20′	72° 30′	72° 40′	δ / ζ
°																	°
1	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.06	89
2	.10	.10	.10	.10	.11	.11	.11	.11	.11	.11	.11	.11	.11	.12	.12	.12	88
3	.15	.16	.16	.16	.16	.16	.16	.16	.16	.17	.17	.17	.17	.17	.17	.18	87
4	.20	.21	.21	.21	.21	.21	.22	.22	.22	.22	.22	.23	.23	.23	.23	.23	86
5	.26	.26	.26	.26	.26	.27	.27	.27	.27	.28	.28	.28	.28	.29	.29	.29	85
6	.31	.31	.31	.32	.32	.32	.32	.33	.33	.33	.34	.34	.34	.34	.35	.35	84
7	.36	.36	.37	.37	.37	.37	.38	.38	.38	.39	.39	.39	.40	.40	.41	.41	83
8	.41	.41	.42	.42	.42	.43	.43	.44	.44	.44	.45	.45	.45	.46	.46	.47	82
9	.46	.46	.47	.47	.48	.48	.48	.49	.49	.50	.50	.51	.51	.52	.52	.52	81
10	.51	.52	.52	.52	.53	.53	.54	.54	.55	.55	.56	.56	.57	.57	.58	.58	80
11	.56	.57	.57	.58	.58	.59	.59	.60	.60	.61	.61	.62	.62	.63	.63	.64	79
12	.61	.62	.62	.63	.63	.64	.64	.65	.66	.66	.67	.67	.68	.68	.69	.70	78
13	.66	.67	.67	.68	.68	.69	.70	.70	.71	.72	.72	.73	.74	.74	.75	.76	77
14	.71	.72	.72	.73	.74	.74	.75	.76	.76	.77	.78	.78	.79	.80	.80	.81	76
15	.76	.77	.78	.78	.79	.79	.80	.81	.81	.82	.83	.84	.84	.85	.86	.87	75
16	.81	.82	.83	.83	.84	.85	.85	.86	.87	.88	.88	.89	.90	.91	.92	.92	74
17	.86	.87	.88	.88	.89	.90	.90	.91	.92	.93	.94	.95	.96	.96	.97	.98	73
18	.91	.92	.93	.93	.94	.95	.96	.96	.97	.98	.99	1.00	1.01	1.02	1.03	1.04	72
19	.96	.97	.98	.98	.99	1.00	1.01	1.02	1.03	1.04	1.04	1.05	1.06	1.07	1.08	1.09	71
20	1.01	1.02	1.02	1.03	1.04	1.05	1.06	1.07	1.08	1.09	1.10	1.11	1.12	1.13	1.14	1.15	70
21	1.06	1.06	1.07	1.08	1.09	1.10	1.11	1.12	1.13	1.14	1.15	1.16	1.17	1.18	1.19	1.20	69
22	1.10	1.11	1.12	1.13	1.14	1.15	1.16	1.17	1.18	1.19	1.20	1.21	1.22	1.24	1.25	1.26	68
23	1.15	1.16	1.17	1.18	1.19	1.20	1.21	1.22	1.23	1.24	1.25	1.26	1.28	1.29	1.30	1.31	67
24	1.20	1.21	1.22	1.23	1.24	1.25	1.26	1.27	1.28	1.29	1.30	1.32	1.33	1.34	1.35	1.36	66
25	1.25	1.26	1.27	1.28	1.29	1.30	1.31	1.32	1.33	1.34	1.36	1.37	1.38	1.39	1.41	1.42	65
26	1.29	1.30	1.31	1.32	1.34	1.35	1.36	1.37	1.38	1.39	1.41	1.42	1.43	1.44	1.46	1.47	64
27	1.34	1.35	1.36	1.37	1.38	1.39	1.41	1.42	1.43	1.44	1.46	1.47	1.48	1.50	1.51	1.52	63
28	1.38	1.40	1.41	1.42	1.43	1.44	1.45	1.47	1.48	1.49	1.51	1.52	1.53	1.55	1.56	1.58	62
29	1.43	1.44	1.45	1.46	1.48	1.49	1.50	1.52	1.53	1.54	1.56	1.57	1.58	1.60	1.61	1.63	61
30	1.47	1.49	1.50	1.51	1.52	1.54	1.55	1.56	1.58	1.59	1.60	1.62	1.63	1.65	1.66	1.68	60
31	1.52	1.53	1.54	1.56	1.57	1.58	1.60	1.61	1.62	1.64	1.65	1.67	1.68	1.70	1.71	1.73	59
32	1.56	1.57	1.59	1.60	1.61	1.63	1.64	1.66	1.67	1.68	1.70	1.71	1.73	1.75	1.76	1.78	58
33	1.60	1.62	1.63	1.64	1.66	1.67	1.69	1.70	1.72	1.73	1.75	1.76	1.78	1.80	1.81	1.83	57
34	1.65	1.66	1.68	1.69	1.70	1.72	1.73	1.75	1.76	1.78	1.79	1.81	1.83	1.84	1.86	1.88	56
35	1.69	1.70	1.72	1.73	1.75	1.76	1.78	1.79	1.81	1.82	1.84	1.86	1.87	1.89	1.91	1.92	55
36	1.73	1.75	1.76	1.78	1.79	1.80	1.82	1.84	1.85	1.87	1.88	1.90	1.92	1.94	1.95	1.97	54
37	1.77	1.79	1.80	1.82	1.83	1.85	1.86	1.88	1.90	1.91	1.93	1.95	1.96	1.98	2.00	2.02	53
38	1.82	1.83	1.84	1.86	1.88	1.89	1.91	1.92	1.94	1.96	1.98	1.99	2.01	2.03	2.05	2.07	52
39	1.86	1.87	1.89	1.90	1.92	1.93	1.95	1.97	1.98	2.00	2.02	2.04	2.06	2.07	2.09	2.11	51
40	1.89	1.91	1.93	1.94	1.96	1.97	1.99	2.01	2.03	2.04	2.06	2.08	2.10	2.12	2.14	2.16	50
41	1.93	1.95	1.96	1.98	2.00	2.01	2.03	2.05	2.07	2.09	2.10	2.12	2.14	2.16	2.18	2.20	49
42	1.97	1.99	2.00	2.02	2.04	2.05	2.07	2.09	2.11	2.13	2.15	2.16	2.18	2.20	2.22	2.25	48
43	2.01	2.03	2.04	2.06	2.08	2.09	2.11	2.13	2.15	2.17	2.19	2.21	2.23	2.25	2.27	2.29	47
44	2.05	2.06	2.08	2.10	2.12	2.13	2.15	2.17	2.19	2.21	2.23	2.25	2.27	2.29	2.31	2.33	46
45	2.08	2.10	2.12	2.14	2.15	2.17	2.19	2.21	2.23	2.25	2.27	2.29	2.31	2.33	2.35	2.37	45
	70° 10′	70° 20′	70° 30′	70° 40′	70° 50′	71°	71° 10′	71° 20′	71° 30′	71° 40′	71° 50′	72°	72° 10′	72° 20′	72° 30′	72° 40′	

Table B-1. Factors For Star Transit Reduction (A,B,C)-Continued

TOP ARGUMENT=STAR'S DECLINATION, δ

SIDE ARGUMENT=STAR'S ZENITH DISTANCE, ζ

[For factor *A* use left-hand argument. For factor *B* use right-hand argument. Factor *C* is on line opposite ζ=90°]

ζ \ δ	70° 10′	70° 20′	70° 30′	70° 40′	70° 50′	71°	71° 10′	71° 20′	71° 30′	71° 40′	71° 50′	72°	72° 10′	72° 20′	72° 30′	72° 40′	δ / ζ
°																	
46	2.12	2.14	2.15	2.17	2.19	2.21	2.23	2.25	2.27	2.29	2.31	2.33	2.35	2.37	2.39	2.41	44
47	2.16	2.17	2.19	2.21	2.23	2.25	2.27	2.28	2.30	2.32	2.35	2.37	2.39	2.41	2.43	2.45	43
48	2.19	2.21	2.22	2.24	2.26	2.28	2.30	2.32	2.34	2.36	2.38	2.40	2.43	2.45	2.47	2.49	42
49	2.22	2.24	2.26	2.28	2.30	2.32	2.34	2.36	2.38	2.40	2.42	2.44	2.46	2.49	2.51	2.53	41
50	2.26	2.28	2.29	2.31	2.33	2.35	2.37	2.39	2.41	2.44	2.46	2.48	2.50	2.52	2.55	2.57	40
51	2.29	2.31	2.33	2.35	2.37	2.39	2.41	2.43	2.45	2.47	2.49	2.51	2.54	2.56	2.58	2.61	39
52	2.32	2.34	2.36	2.38	2.40	2.42	2.44	2.46	2.48	2.50	2.53	2.55	2.57	2.60	2.62	2.64	38
53	2.35	2.37	2.39	2.41	2.43	2.45	2.47	2.50	2.52	2.54	2.56	2.58	2.61	2.63	2.66	2.68	37
54	2.38	2.40	2.42	2.44	2.46	2.48	2.51	2.53	2.55	2.57	2.60	2.62	2.64	2.67	2.69	2.72	36
55	2.41	2.43	2.45	2.47	2.50	2.52	2.54	2.56	2.58	2.60	2.63	2.65	2.68	2.70	2.72	2.75	35
56	2.44	2.46	2.48	2.50	2.52	2.55	2.57	2.59	2.61	2.64	2.66	2.68	2.71	2.73	2.76	2.78	34
57	2.47	2.49	2.51	2.53	2.55	2.58	2.60	2.62	2.64	2.67	2.69	2.71	2.74	2.76	2.79	2.82	33
58	2.50	2.52	2.54	2.56	2.58	2.61	2.63	2.65	2.67	2.70	2.72	2.74	2.77	2.79	2.82	2.85	32
59	2.53	2.55	2.57	2.59	2.61	2.63	2.66	2.68	2.70	2.72	2.75	2.77	2.80	2.82	2.85	2.88	31
60	2.55	2.57	2.59	2.62	2.64	2.66	2.68	2.71	2.73	2.75	2.78	2.80	2.83	2.85	2.88	2.91	30
61	2.58	2.60	2.62	2.64	2.66	2.69	2.71	2.73	2.76	2.78	2.80	2.83	2.86	2.88	2.91	2.94	29
62	2.60	2.62	2.64	2.67	2.69	2.71	2.74	2.76	2.78	2.81	2.83	2.86	2.88	2.91	2.94	2.96	28
63	2.63	2.65	2.67	2.69	2.71	2.74	2.76	2.78	2.81	2.83	2.86	2.88	2.91	2.94	2.96	2.99	27
64	2.65	2.67	2.69	2.72	2.74	2.76	2.78	2.81	2.83	2.86	2.88	2.91	2.94	2.96	2.99	3.02	26
65	2.67	2.69	2.71	2.74	2.76	2.78	2.81	2.83	2.86	2.88	2.91	2.93	2.96	2.99	3.01	3.04	25
66	2.69	2.71	2.74	2.76	2.78	2.81	2.83	2.85	2.88	2.90	2.93	2.96	2.98	3.01	3.04	3.07	24
67	2.71	2.74	2.76	2.78	2.80	2.83	2.85	2.88	2.90	2.93	2.95	2.98	3.01	3.03	3.06	3.09	23
68	2.73	2.76	2.78	2.80	2.82	2.85	2.87	2.90	2.92	2.95	2.97	3.00	3.03	3.06	3.08	3.11	22
69	2.75	2.77	2.80	2.82	2.84	2.87	2.89	2.92	2.94	2.97	2.99	3.02	3.05	3.08	3.10	3.13	21
70	2.77	2.79	2.81	2.84	2.86	2.89	2.91	2.94	2.96	2.99	3.01	3.04	3.07	3.10	3.12	3.15	20
71	2.79	2.81	2.83	2.86	2.88	2.90	2.93	2.95	2.98	3.01	3.03	3.06	3.09	3.12	3.14	3.17	19
72	2.80	2.83	2.85	2.87	2.90	2.92	2.95	2.97	3.00	3.02	3.05	3.08	3.10	3.13	3.16	3.19	18
73	2.82	2.84	2.86	2.89	2.91	2.94	2.96	2.99	3.01	3.04	3.07	3.09	3.12	3.15	3.18	3.21	17
74	2.83	2.86	2.88	2.90	2.93	2.95	2.98	3.00	3.03	3.06	3.08	3.11	3.14	3.17	3.20	3.23	16
75	2.85	2.87	2.89	2.92	2.94	2.97	2.99	3.02	3.04	3.07	3.10	3.13	3.15	3.18	3.21	3.24	15
76	2.86	2.88	2.91	2.93	2.96	2.98	3.01	3.03	3.06	3.08	3.11	3.14	3.17	3.20	3.23	3.26	14
77	2.87	2.90	2.92	2.94	2.97	2.99	3.02	3.04	3.07	3.10	3.12	3.15	3.18	3.21	3.24	3.27	13
78	2.88	2.91	2.93	2.95	2.98	3.00	3.03	3.06	3.08	3.11	3.14	3.16	3.19	3.22	3.25	3.28	12
79	2.89	2.92	2.94	2.96	2.99	3.02	3.04	3.07	3.09	3.12	3.15	3.18	3.20	3.23	3.26	3.29	11
80	2.90	2.93	2.95	2.97	3.00	3.02	3.05	3.08	3.10	3.13	3.16	3.19	3.22	3.24	3.27	3.31	10
81	2.91	2.94	2.96	2.98	3.01	3.03	3.06	3.09	3.11	3.14	3.17	3.20	3.23	3.25	3.28	3.32	9
82	2.92	2.94	2.97	2.99	3.02	3.04	3.07	3.09	3.12	3.15	3.18	3.20	3.23	3.26	3.29	3.32	8
83	2.92	2.95	2.97	3.00	3.02	3.05	3.08	3.10	3.13	3.16	3.18	3.21	3.24	3.27	3.30	3.33	7
84	2.93	2.96	2.98	3.00	3.03	3.06	3.08	3.11	3.13	3.16	3.19	3.22	3.25	3.28	3.31	3.34	6
85	2.94	2.96	2.98	3.01	3.03	3.06	3.09	3.11	3.14	3.17	3.20	3.22	3.25	3.28	3.31	3.34	5
86	2.94	2.96	2.99	3.01	3.04	3.06	3.09	3.12	3.14	3.17	3.20	3.23	3.26	3.29	3.32	3.35	4
87	2.94	2.97	2.99	3.02	3.04	3.07	3.09	3.12	3.15	3.18	3.20	3.23	3.26	3.29	3.32	3.35	3
88	2.95	2.97	2.99	3.02	3.04	3.07	3.10	3.12	3.15	3.18	3.20	3.23	3.26	3.29	3.32	3.35	2
89	2.95	2.97	3.00	3.02	3.04	3.07	3.10	3.12	3.15	3.18	3.21	3.24	3.27	3.30	3.33	3.36	1
90	2.95	2.97	3.00	3.02	3.05	3.07	3.10	3.12	3.15	3.18	3.21	3.24	3.27	3.30	3.33	3.36	0
	70° 10′	70° 20′	70° 30′	70° 40′	70° 50′	71°	71° 10′	71° 20′	71° 30′	71° 40′	71° 50′	72°	72° 10′	72° 20′	72° 30′	72° 40′	

Table B-1. Factors For Star Transit Reduction (A,B,C)-Continued

TOP ARGUMENT=STAR'S DECLINATION, δ

SIDE ARGUMENT=STAR'S ZENITH DISTANCE, ζ

[For factor *A* use left-hand argument. For factor *B* use right-hand argument. Factor *C* is on bottom line of next page]

δ / ζ	72° 40′	72° 50′	73°	73° 10′	73° 20′	73° 30′	73° 40′	73° 50′	74°	74° 10′	74° 20′	74° 30′	74° 40′	74° 50′	75°	75° 10′	δ / ζ
°																	°
1	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.07	89
2	.12	.12	.12	.12	.12	.12	.12	.12	.13	.13	.13	.13	.13	.13	.13	.14	88
3	.18	.18	.18	.18	.18	.18	.19	.19	.19	.19	.19	.20	.20	.20	.20	.20	87
4	.23	.24	.24	.24	.24	.24	.25	.25	.25	.26	.26	.26	.26	.27	.27	.27	86
5	.29	.30	.30	.30	.30	.31	.31	.31	.32	.32	.32	.33	.33	.33	.34	.34	85
6	.35	.35	.36	.36	.36	.37	.37	.38	.38	.38	.39	.39	.40	.40	.40	.41	84
7	.41	.41	.42	.42	.42	.43	.43	.44	.44	.45	.45	.46	.46	.47	.47	.48	83
8	.47	.47	.48	.48	.48	.49	.50	.50	.50	.51	.52	.52	.53	.53	.54	.54	82
9	.52	.53	.53	.54	.54	.55	.56	.56	.57	.57	.58	.58	.59	.60	.60	.61	81
10	.58	.59	.59	.60	.60	.61	.62	.62	.63	.64	.64	.65	.66	.66	.67	.68	80
11	.64	.65	.65	.66	.66	.67	.68	.68	.69	.70	.71	.71	.72	.73	.74	.74	79
12	.70	.70	.71	.72	.72	.73	.74	.75	.75	.76	.77	.78	.79	.79	.80	.81	78
13	.76	.76	.77	.78	.78	.79	.80	.81	.82	.82	.83	.84	.85	.86	.87	.88	77
14	.81	.82	.83	.84	.84	.85	.86	.87	.88	.89	.90	.91	.92	.93	.94	.95	76
15	.87	.88	.89	.89	.90	.91	.92	.93	.94	.95	.96	.97	.98	.99	1.00	1.01	75
16	.92	.93	.94	.95	.96	.97	.98	.99	1.00	1.01	1.02	1.03	1.04	1.05	1.06	1.08	74
17	.98	.99	1.00	1.01	1.02	1.03	1.04	1.05	1.06	1.07	1.08	1.09	1.11	1.12	1.13	1.14	73
18	1.04	1.05	1.06	1.07	1.08	1.09	1.10	1.11	1.12	1.13	1.14	1.16	1.17	1.18	1.19	1.21	72
19	1.09	1.10	1.11	1.12	1.14	1.15	1.16	1.17	1.18	1.19	1.21	1.22	1.23	1.24	1.26	1.27	71
20	1.15	1.16	1.17	1.18	1.19	1.20	1.22	1.23	1.24	1.25	1.27	1.28	1.29	1.31	1.32	1.34	70
21	1.20	1.21	1.22	1.24	1.25	1.26	1.27	1.29	1.30	1.31	1.33	1.34	1.36	1.37	1.38	1.40	69
22	1.26	1.27	1.28	1.29	1.31	1.32	1.33	1.34	1.36	1.37	1.39	1.40	1.42	1.43	1.45	1.46	68
23	1.31	1.32	1.34	1.35	1.36	1.38	1.39	1.40	1.42	1.43	1.45	1.46	1.48	1.49	1.51	1.53	67
24	1.36	1.38	1.39	1.40	1.42	1.43	1.45	1.46	1.48	1.49	1.51	1.52	1.54	1.55	1.57	1.59	66
25	1.42	1.43	1.45	1.46	1.47	1.49	1.50	1.52	1.53	1.55	1.56	1.58	1.60	1.62	1.63	1.65	65
26	1.47	1.48	1.50	1.51	1.53	1.54	1.56	1.58	1.59	1.61	1.62	1.64	1.66	1.68	1.69	1.71	64
27	1.52	1.54	1.55	1.57	1.58	1.60	1.61	1.63	1.65	1.66	1.68	1.70	1.72	1.74	1.75	1.77	63
28	1.58	1.59	1.60	1.62	1.64	1.65	1.67	1.69	1.70	1.72	1.74	1.76	1.78	1.79	1.81	1.83	62
29	1.63	1.64	1.66	1.67	1.69	1.71	1.72	1.74	1.76	1.78	1.80	1.81	1.83	1.85	1.87	1.89	61
30	1.68	1.69	1.71	1.73	1.74	1.76	1.78	1.80	1.81	1.83	1.85	1.87	1.89	1.91	1.93	1.95	60
31	1.73	1.74	1.76	1.78	1.80	1.81	1.83	1.85	1.87	1.89	1.91	1.93	1.95	1.97	1.99	2.01	59
32	1.78	1.80	1.81	1.83	1.85	1.87	1.88	1.90	1.92	1.94	1.96	1.98	2.00	2.02	2.05	2.07	58
33	1.83	1.85	1.86	1.88	1.90	1.92	1.94	1.96	1.98	2.00	2.02	2.04	2.06	2.08	2.10	2.13	57
34	1.88	1.89	1.91	1.93	1.95	1.97	1.99	2.01	2.03	2.05	2.07	2.09	2.12	2.14	2.16	2.18	56
35	1.92	1.94	1.96	1.98	2.00	2.02	2.04	2.06	2.08	2.10	2.12	2.15	2.17	2.19	2.22	2.24	55
36	1.97	1.99	2.01	2.03	2.05	2.07	2.09	2.11	2.13	2.15	2.18	2.20	2.22	2.25	2.27	2.30	54
37	2.02	2.04	2.06	2.08	2.10	2.12	2.14	2.16	2.18	2.21	2.23	2.25	2.28	2.30	2.33	2.35	53
38	2.07	2.09	2.11	2.13	2.15	2.17	2.19	2.21	2.23	2.26	2.28	2.30	2.33	2.35	2.38	2.40	52
39	2.11	2.13	2.15	2.17	2.19	2.22	2.24	2.26	2.28	2.31	2.33	2.35	2.38	2.40	2.43	2.46	51
40	2.16	2.18	2.20	2.22	2.24	2.26	2.29	2.31	2.33	2.36	2.38	2.40	2.43	2.46	2.48	2.51	50
41	2.20	2.22	2.24	2.26	2.29	2.31	2.33	2.36	2.38	2.40	2.43	2.45	2.48	2.51	2.53	2.56	49
42	2.25	2.27	2.29	2.31	2.33	2.36	2.38	2.40	2.43	2.45	2.48	2.50	2.53	2.56	2.58	2.61	48
43	2.29	2.31	2.33	2.36	2.38	2.40	2.42	2.45	2.47	2.50	2.53	2.55	2.58	2.61	2.63	2.66	47
44	2.33	2.35	2.38	2.40	2.42	2.45	2.47	2.50	2.52	2.55	2.57	2.60	2.63	2.66	2.68	2.71	46
45	2.37	2.40	2.42	2.44	2.46	2.49	2.51	2.54	2.56	2.59	2.62	2.65	2.67	2.70	2.73	2.76	45
	72° 40′	72° 50′	73°	73° 10′	73° 20′	73° 30′	73° 40′	73° 50′	74°	74° 10′	74° 20′	74° 30′	74° 40′	74° 50′	75°	75° 10′	

Table B-1. Factors For Star Transit Reduction (A,B,C)-Continued

TOP ARGUMENT=STAR'S DECLINATION, δ

SIDE ARGUMENT=STAR'S ZENITH DISTANCE, ζ

[For factor *A* use left-hand argument. For factor *B* use right-hand argument. Factor *C* is on line opposite ζ=90°]

ζ \ δ	72° 40′	72° 50′	73°	73° 10′	73° 20′	73° 30′	73° 40′	73° 50′	74°	74° 10′	74° 20′	74° 30′	74° 40′	74° 50′	75°	75° 10′	δ / ζ
°																	°
46	2.41	2.44	2.46	2.48	2.51	2.53	2.56	2.58	2.61	2.64	2.66	2.69	2.72	2.75	2.78	2.81	44
47	2.45	2.48	2.50	2.52	2.55	2.57	2.60	2.63	2.65	2.68	2.71	2.74	2.77	2.80	2.83	2.86	43
48	2.49	2.52	2.54	2.57	2.59	2.62	2.64	2.67	2.70	2.72	2.75	2.78	2.81	2.84	2.87	2.90	42
49	2.53	2.56	2.58	2.61	2.63	2.66	2.68	2.71	2.74	2.77	2.80	2.82	2.85	2.88	2.92	2.95	41
50	2.57	2.60	2.62	2.64	2.67	2.70	2.72	2.75	2.78	2.81	2.84	2.87	2.90	2.93	2.96	2.99	40
51	2.61	2.63	2.66	2.68	2.71	2.74	2.76	2.79	2.82	2.85	2.88	2.91	2.94	2.97	3.00	3.04	39
52	2.64	2.67	2.69	2.72	2.75	2.77	2.80	2.83	2.86	2.89	2.92	2.95	2.98	3.01	3.04	3.08	38
53	2.68	2.71	2.73	2.76	2.78	2.81	2.84	2.87	2.90	2.93	2.96	2.99	3.02	3.05	3.09	3.12	37
54	2.72	2.74	2.77	2.79	2.82	2.85	2.88	2.91	2.94	2.97	3.00	3.03	3.06	3.09	3.13	3.16	36
55	2.75	2.78	2.80	2.83	2.86	2.88	2.91	2.94	2.97	3.00	3.03	3.07	3.10	3.13	3.16	3.20	35
56	2.78	2.81	2.84	2.86	2.89	2.92	2.95	2.98	3.01	3.04	3.07	3.10	3.14	3.17	3.20	3.24	34
57	2.82	2.84	2.87	2.90	2.92	2.95	2.98	3.01	3.04	3.07	3.11	3.14	3.17	3.21	3.24	3.28	33
58	2.85	2.87	2.90	2.93	2.96	2.99	3.02	3.05	3.08	3.11	3.14	3.17	3.21	3.24	3.28	3.31	32
59	2.88	2.90	2.93	2.96	2.99	3.02	3.05	3.08	3.11	3.14	3.17	3.21	3.24	3.28	3.31	3.35	31
60	2.91	2.93	2.96	2.99	3.02	3.05	3.08	3.11	3.14	3.17	3.21	3.24	3.28	3.31	3.35	3.38	30
61	2.94	2.96	2.99	3.02	3.05	3.08	3.11	3.14	3.17	3.21	3.24	3.27	3.31	3.34	3.38	3.42	29
62	2.96	2.99	3.02	3.05	3.08	3.11	3.14	3.17	3.20	3.24	3.27	3.30	3.34	3.38	3.41	3.45	28
63	2.99	3.02	3.05	3.08	3.11	3.14	3.17	3.20	3.23	3.27	3.30	3.33	3.37	3.41	3.44	3.48	27
64	3.02	3.04	3.07	3.10	3.13	3.16	3.20	3.23	3.26	3.29	3.33	3.36	3.40	3.44	3.47	3.51	26
65	3.04	3.07	3.10	3.13	3.16	3.19	3.22	3.26	3.29	3.32	3.36	3.39	3.43	3.46	3.50	3.54	25
66	3.07	3.10	3.13	3.16	3.18	3.22	3.25	3.28	3.31	3.35	3.38	3.42	3.46	3.49	3.53	3.57	24
67	3.09	3.12	3.15	3.18	3.21	3.24	3.27	3.31	3.34	3.37	3.41	3.44	3.48	3.52	3.56	3.60	23
68	3.11	3.14	3.17	3.20	3.23	3.26	3.30	3.33	3.36	3.40	3.43	3.47	3.51	3.54	3.58	3.62	22
69	3.13	3.16	3.19	3.22	3.26	3.29	3.32	3.35	3.39	3.42	3.46	3.49	3.53	3.57	3.61	3.65	21
70	3.15	3.18	3.21	3.24	3.28	3.31	3.34	3.38	3.41	3.44	3.48	3.52	3.55	3.59	3.63	3.67	20
71	3.17	3.20	3.23	3.26	3.30	3.33	3.36	3.40	3.43	3.47	3.50	3.54	3.58	3.61	3.65	3.69	19
72	3.19	3.22	3.25	3.28	3.32	3.35	3.38	3.42	3.45	3.49	3.52	3.56	3.60	3.63	3.67	3.72	18
73	3.21	3.24	3.27	3.30	3.33	3.37	3.40	3.44	3.47	3.50	3.54	3.58	3.62	3.65	3.69	3.74	17
74	3.23	3.26	3.29	3.32	3.35	3.38	3.42	3.45	3.49	3.52	3.56	3.60	3.64	3.67	3.71	3.76	16
75	3.24	3.27	3.30	3.34	3.37	3.40	3.44	3.47	3.50	3.54	3.58	3.61	3.65	3.69	3.73	3.77	15
76	3.26	3.29	3.32	3.35	3.38	3.42	3.45	3.48	3.52	3.56	3.59	3.63	3.67	3.71	3.75	3.79	14
77	3.27	3.30	3.33	3.36	3.40	3.43	3.46	3.50	3.54	3.57	3.61	3.65	3.68	3.72	3.76	3.81	13
78	3.28	3.31	3.34	3.38	3.41	3.44	3.48	3.51	3.55	3.58	3.62	3.66	3.70	3.74	3.78	3.82	12
79	3.29	3.33	3.36	3.39	3.42	3.46	3.49	3.53	3.56	3.60	3.64	3.67	3.71	3.75	3.79	3.83	11
80	3.31	3.34	3.37	3.40	3.43	3.47	3.50	3.54	3.57	3.61	3.65	3.68	3.72	3.76	3.81	3.85	10
81	3.32	3.35	3.38	3.41	3.44	3.48	3.51	3.55	3.58	3.62	3.66	3.70	3.74	3.78	3.82	3.86	9
82	3.32	3.36	3.39	3.42	3.45	3.49	3.52	3.56	3.59	3.63	3.67	3.71	3.75	3.79	3.83	3.87	8
83	3.33	3.36	3.40	3.43	3.46	3.49	3.53	3.56	3.60	3.64	3.68	3.72	3.75	3.79	3.84	3.88	7
84	3.34	3.37	3.40	3.43	3.47	3.50	3.54	3.57	3.61	3.64	3.68	3.72	3.76	3.80	3.84	3.88	6
85	3.34	3.38	3.41	3.44	3.47	3.51	3.54	3.58	3.61	3.65	3.69	3.73	3.77	3.81	3.85	3.89	5
86	3.35	3.38	3.41	3.44	3.48	3.51	3.55	3.58	3.62	3.66	3.69	3.73	3.77	3.81	3.85	3.90	4
87	3.35	3.38	3.42	3.45	3.48	3.52	3.55	3.59	3.62	3.66	3.70	3.74	3.78	3.82	3.86	3.90	3
88	3.35	3.39	3.42	3.45	3.48	3.52	3.55	3.59	3.62	3.66	3.70	3.74	3.78	3.82	3.86	3.90	2
89	3.36	3.39	3.42	3.45	3.49	3.52	3.56	3.59	3.63	3.66	3.70	3.74	3.78	3.82	3.86	3.91	1
90	3.36	3.39	3.42	3.45	3.49	3.52	3.56	3.59	3.63	3.66	3.70	3.74	3.78	3.82	3.86	3.91	0
	72° 40′	72° 50′	73°	73° 10′	73° 20′	73° 30′	73° 40′	73° 50′	74°	74° 10′	74° 20′	74° 30′	74° 40′	74° 50′	75°	75° 10′	

Table B-1, Factors For Star Transit Reduction (A,B,C)-Continued

TOP ARGUMENT=STAR'S DECLINATION, δ
SIDE ARGUMENT=STAR'S ZENITH DISTANCE, ζ
[For factor *A* use left-hand argument. For factor *B* use right-hand argument. Factor *C* is on bottom line of next page]

ζ \ δ	75° 10′	75° 20′	75° 30′	75° 40′	75° 50′	76°	76° 10′	76° 20′	76° 30′	76° 40′	76° 50′	77°	77° 10′	77° 20′	77° 30′	77° 40′	δ / ζ
°																	°
1	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.08	0.08	0.08	0.08	89
2	.14	.14	.14	.14	.14	.14	.15	.15	.15	.15	.15	.16	.16	.16	.16	.16	88
3	.20	.21	.21	.21	.21	.22	.22	.22	.22	.23	.23	.23	.24	.24	.24	.24	87
4	.27	.28	.28	.28	.28	.29	.29	.30	.30	.30	.31	.31	.31	.32	.32	.33	86
5	.34	.34	.35	.35	.36	.36	.36	.37	.37	.38	.38	.39	.39	.40	.40	.41	85
6	.41	.41	.42	.42	.43	.43	.44	.44	.45	.45	.46	.46	.47	.48	.48	.49	84
7	.48	.48	.49	.49	.50	.50	.51	.52	.52	.53	.54	.54	.55	.56	.56	.57	83
8	.54	.55	.56	.56	.57	.58	.58	.59	.60	.60	.61	.62	.63	.64	.64	.65	82
9	.61	.62	.62	.63	.64	.65	.65	.66	.67	.68	.69	.70	.70	.71	.72	.73	81
10	.68	.69	.69	.70	.71	.72	.73	.74	.74	.75	.76	.77	.78	.79	.80	.81	80
11	.74	.75	.76	.77	.78	.79	.80	.81	.82	.83	.84	.85	.86	.87	.88	.89	79
12	.81	.82	.83	.84	.85	.86	.87	.88	.89	.90	.91	.92	.94	.95	.96	.97	78
13	.88	.89	.90	.91	.92	.93	.94	.95	.96	.98	.99	1.00	1.01	1.03	1.04	1.05	77
14	.95	.96	.97	.98	.99	1.00	1.01	1.02	1.04	1.05	1.06	1.08	1.09	1.10	1.12	1.13	76
15	1.01	1.02	1.03	1.04	1.06	1.07	1.08	1.10	1.11	1.12	1.14	1.15	1.16	1.18	1.20	1.21	75
16	1.08	1.09	1.10	1.11	1.13	1.14	1.15	1.17	1.18	1.20	1.21	1.23	1.24	1.26	1.28	1.29	74
17	1.14	1.16	1.17	1.18	1.20	1.21	1.22	1.24	1.25	1.27	1.28	1.30	1.32	1.33	1.35	1.37	73
18	1.21	1.22	1.23	1.25	1.26	1.28	1.29	1.31	1.32	1.34	1.36	1.37	1.39	1.41	1.43	1.45	72
19	1.27	1.29	1.30	1.32	1.33	1.35	1.36	1.38	1.39	1.41	1.43	1.45	1.47	1.48	1.50	1.52	71
20	1.34	1.35	1.37	1.38	1.40	1.41	1.43	1.45	1.47	1.48	1.50	1.52	1.54	1.56	1.58	1.60	70
21	1.40	1.42	1.43	1.45	1.46	1.48	1.50	1.52	1.54	1.55	1.57	1.59	1.61	1.63	1.65	1.68	69
22	1.46	1.48	1.50	1.51	1.53	1.55	1.57	1.58	1.60	1.62	1.64	1.66	1.69	1.71	1.73	1.75	68
23	1.53	1.54	1.56	1.58	1.60	1.62	1.63	1.65	1.67	1.69	1.72	1.74	1.76	1.78	1.81	1.83	67
24	1.59	1.61	1.63	1.64	1.66	1.68	1.70	1.72	1.74	1.76	1.79	1.81	1.83	1.86	1.88	1.90	66
25	1.65	1.67	1.69	1.71	1.73	1.75	1.77	1.79	1.81	1.83	1.86	1.88	1.90	1.93	1.95	1.98	65
26	1.71	1.73	1.75	1.77	1.79	1.81	1.83	1.86	1.88	1.90	1.92	1.95	1.97	2.00	2.02	2.05	64
27	1.77	1.79	1.81	1.83	1.86	1.88	1.90	1.92	1.95	1.97	1.99	2.02	2.04	2.07	2.10	2.12	63
28	1.83	1.85	1.87	1.90	1.92	1.94	1.96	1.99	2.01	2.04	2.06	2.09	2.11	2.14	2.17	2.20	62
29	1.89	1.92	1.94	1.96	1.98	2.00	2.03	2.05	2.08	2.10	2.13	2.15	2.18	2.21	2.24	2.27	61
30	1.95	1.98	2.00	2.02	2.04	2.07	2.09	2.12	2.14	2.17	2.20	2.22	2.25	2.28	2.31	2.34	60
31	2.01	2.03	2.06	2.08	2.10	2.13	2.15	2.18	2.21	2.23	2.26	2.29	2.32	2.35	2.38	2.41	59
32	2.07	2.09	2.12	2.14	2.16	2.19	2.22	2.24	2.27	2.30	2.33	2.36	2.39	2.42	2.45	2.48	58
33	2.13	2.15	2.18	2.20	2.22	2.25	2.28	2.30	2.33	2.36	2.39	2.42	2.45	2.48	2.52	2.55	57
34	2.18	2.21	2.23	2.26	2.28	2.31	2.34	2.37	2.40	2.42	2.46	2.49	2.52	2.55	2.58	2.62	56
35	2.24	2.26	2.29	2.32	2.34	2.37	2.40	2.43	2.46	2.49	2.52	2.55	2.58	2.62	2.65	2.68	55
36	2.30	2.32	2.35	2.37	2.40	2.43	2.46	2.49	2.52	2.55	2.58	2.61	2.65	2.68	2.72	2.75	54
37	2.35	2.38	2.40	2.43	2.46	2.49	2.52	2.55	2.58	2.61	2.64	2.67	2.71	2.74	2.78	2.82	53
38	2.40	2.43	2.46	2.49	2.52	2.55	2.58	2.61	2.64	2.67	2.70	2.74	2.77	2.81	2.85	2.88	52
39	2.46	2.49	2.51	2.54	2.57	2.60	2.63	2.66	2.70	2.73	2.76	2.80	2.83	2.87	2.91	2.95	51
40	2.51	2.54	2.57	2.60	2.63	2.66	2.69	2.72	2.75	2.79	2.82	2.86	2.89	2.93	2.97	3.01	50
41	2.56	2.59	2.62	2.65	2.68	2.71	2.74	2.78	2.81	2.84	2.88	2.92	2.95	2.99	3.03	3.07	49
42	2.61	2.64	2.67	2.70	2.73	2.77	2.80	2.83	2.87	2.90	2.94	2.97	3.01	3.05	3.09	3.13	48
43	2.66	2.69	2.72	2.76	2.79	2.82	2.85	2.89	2.92	2.96	2.99	3.03	3.07	3.11	3.15	3.19	47
44	2.71	2.74	2.77	2.81	2.84	2.87	2.90	2.94	2.98	3.01	3.05	3.09	3.13	3.17	3.21	3.25	46
45	2.76	2.79	2.82	2.86	2.89	2.92	2.96	2.99	3.03	3.07	3.10	3.14	3.18	3.22	3.27	3.31	45
	75° 10′	75° 20′	75° 30′	75° 40′	75° 50′	76°	76° 10′	76° 20′	76° 30′	76° 40′	76° 50′	77°	77° 10′	77° 20′	77° 30′	77° 40′	

Table B-1. Factors For Star Transit Reduction (A,B,C)-Continued

TOP ARGUMENT=STAR'S DECLINATION, δ

SIDE ARGUMENT=STAR'S ZENITH DISTANCE, ζ

[For factor *A* use left-hand argument. For factor *B* use right-hand argument. Factor *C* is on line opposite ζ=90°]

ζ \ δ	75° 10′	75° 20′	75° 30′	75° 40′	75°50′	76°	76° 10′	76° 20′	76° 30′	76° 40′	76° 50′	77°	77° 10′	77° 20′	77° 30′	77° 40′	δ / ζ
°																	°
46	2.81	2.84	2.87	2.91	2.94	2.97	3.01	3.04	3.08	3.12	3.16	3.20	3.24	3.28	3.32	3.37	44
47	2.86	2.89	2.92	2.95	2.99	3.02	3.06	3.10	3.13	3.17	3.21	3.25	3.29	3.34	3.38	3.42	43
48	2.90	2.94	2.97	3.00	3.04	3.07	3.11	3.15	3.18	3.22	3.26	3.30	3.35	3.39	3.43	3.48	42
49	2.95	2.98	3.01	3.05	3.08	3.12	3.16	3.19	3.23	3.27	3.31	3.36	3.40	3.44	3.49	3.53	41
50	2.99	3.02	3.06	3.09	3.13	3.17	3.20	3.24	3.28	3.32	3.36	3.41	3.45	3.49	3.54	3.59	40
51	3.04	3.07	3.10	3.14	3.18	3.21	3.25	3.29	3.33	3.37	3.41	3.45	3.50	3.54	3.59	3.64	39
52	3.08	3.11	3.15	3.18	3.22	3.26	3.30	3.34	3.38	3.42	3.46	3.50	3.55	3.59	3.64	3.69	38
53	3.12	3.15	3.19	3.23	3.26	3.30	3.34	3.38	3.42	3.46	3.51	3.55	3.60	3.64	3.69	3.74	37
54	3.16	3.20	3.23	3.27	3.31	3.34	3.38	3.42	3.47	3.51	3.55	3.60	3.64	3.69	3.74	3.79	36
55	3.20	3.24	3.27	3.31	3.35	3.39	3.43	3.47	3.51	3.55	3.60	3.64	3.69	3.74	3.78	3.83	35
56	3.24	3.27	3.31	3.35	3.39	3.43	3.47	3.51	3.55	3.60	3.64	3.68	3.73	3.78	3.83	3.88	34
57	3.28	3.31	3.35	3.39	3.43	3.47	3.51	3.55	3.59	3.64	3.68	3.73	3.78	3.83	3.88	3.93	33
58	3.31	3.35	3.39	3.43	3.47	3.51	3.55	3.59	3.63	3.68	3.72	3.77	3.82	3.87	3.92	3.97	32
59	3.35	3.38	3.42	3.46	3.50	3.54	3.58	3.63	3.67	3.72	3.76	3.81	3.86	3.91	3.96	4.01	31
60	3.38	3.42	3.46	3.50	3.54	3.58	3.62	3.66	3.71	3.76	3.80	3.85	3.90	3.95	4.00	4.05	30
61	3.42	3.45	3.49	3.53	3.57	3.62	3.66	3.70	3.75	3.79	3.84	3.89	3.94	3.99	4.04	4.09	29
62	3.45	3.49	3.53	3.57	3.61	3.65	3.69	3.74	3.78	3.83	3.88	3.93	3.98	4.03	4.08	4.13	28
63	3.48	3.52	3.56	3.60	3.64	3.68	3.73	3.77	3.82	3.86	3.91	3.96	4.01	4.06	4.12	4.17	27
64	3.51	3.55	3.59	3.63	3.67	3.72	3.76	3.80	3.85	3.90	3.95	4.00	4.05	4.10	4.15	4.21	26
65	3.54	3.58	3.62	3.66	3.70	3.75	3.79	3.84	3.88	3.93	3.98	4.03	4.08	4.13	4.19	4.24	25
66	3.57	3.61	3.65	3.69	3.73	3.78	3.82	3.87	3.91	3.96	4.01	4.06	4.11	4.17	4.22	4.28	24
67	3.60	3.64	3.68	3.72	3.76	3.81	3.85	3.90	3.94	3.99	4.04	4.09	4.14	4.20	4.25	4.31	23
68	3.62	3.66	3.70	3.74	3.79	3.83	3.88	3.92	3.97	4.02	4.07	4.12	4.17	4.23	4.28	4.34	22
69	3.65	3.69	3.73	3.77	3.82	3.86	3.90	3.95	4.00	4.05	4.10	4.15	4.20	4.26	4.31	4.37	21
70	3.67	3.71	3.75	3.80	3.84	3.89	3.93	3.98	4.03	4.08	4.12	4.18	4.23	4.28	4.34	4.40	20
71	3.69	3.73	3.78	3.82	3.86	3.91	3.96	4.00	4.05	4.10	4.15	4.20	4.26	4.31	4.37	4.43	19
72	3.72	3.76	3.80	3.84	3.89	3.93	3.98	4.02	4.07	4.12	4.18	4.23	4.28	4.34	4.39	4.45	18
73	3.74	3.78	3.82	3.86	3.91	3.95	4.00	4.05	4.10	4.15	4.20	4.25	4.30	4.36	4.42	4.48	17
74	3.76	3.80	3.84	3.88	3.93	3.97	4.02	4.07	4.12	4.17	4.22	4.27	4.33	4.38	4.44	4.50	16
75	3.77	3.82	3.86	3.90	3.95	3.99	4.04	4.09	4.14	4.19	4.24	4.29	4.35	4.40	4.46	4.52	15
76	3.79	3.83	3.88	3.92	3.96	4.01	4.06	4.11	4.16	4.21	4.26	4.31	4.37	4.42	4.48	4.54	14
77	3.81	3.85	3.89	3.94	3.98	4.03	4.08	4.12	4.17	4.22	4.28	4.33	4.39	4.44	4.50	4.56	13
78	3.82	3.86	3.91	3.95	4.00	4.04	4.09	4.14	4.19	4.24	4.29	4.35	4.40	4.46	4.52	4.58	12
79	3.83	3.88	3.92	3.96	4.01	4.06	4.11	4.16	4.21	4.26	4.31	4.36	4.42	4.48	4.54	4.60	11
80	3.85	3.89	3.93	3.98	4.02	4.07	4.12	4.17	4.22	4.27	4.32	4.38	4.43	4.49	4.55	4.61	10
81	3.86	3.90	3.94	3.99	4.04	4.08	4.13	4.18	4.23	4.28	4.34	4.39	4.45	4.50	4.56	4.62	9
82	3.87	3.91	3.96	4.00	4.05	4.09	4.14	4.19	4.24	4.29	4.35	4.40	4.46	4.52	4.58	4.64	8
83	3.88	3.92	3.96	4.01	4.06	4.10	4.15	4.20	4.25	4.30	4.36	4.41	4.47	4.53	4.59	4.65	7
84	3.88	3.93	3.97	4.02	4.06	4.11	4.16	4.21	4.26	4.31	4.37	4.42	4.48	4.54	4.60	4.66	6
85	3.89	3.93	3.98	4.02	4.07	4.12	4.17	4.22	4.27	4.32	4.37	4.43	4.48	4.54	4.60	4.66	5
86	3.90	3.94	3.98	4.03	4.08	4.12	4.17	4.22	4.27	4.33	4.38	4.43	4.49	4.55	4.61	4.67	4
87	3.90	3.94	3.99	4.03	4.08	4.13	4.18	4.23	4.28	4.33	4.38	4.44	4.50	4.55	4.61	4.68	3
88	3.90	3.95	3.99	4.04	4.08	4.13	4.18	4.23	4.28	4.33	4.39	4.44	4.50	4.56	4.62	4.68	2
89	3.91	3.95	3.99	4.04	4.08	4.13	4.18	4.23	4.28	4.34	4.39	4.44	4.50	4.56	4.62	4.68	1
90	3.91	3.95	3.99	4.04	4.09	4.13	4.18	4.23	4.28	4.34	4.39	4.44	4.50	4.56	4.62	4.68	0
	75° 10′	75° 20′	75° 30′	75° 40′	75° 50′	76°	76° 10′	76° 20′	76° 30′	76° 40′	76° 50′	77°	77° 10′	77° 20′	77° 30′	77° 40′	

Table B-1. Factors For Star Transit Reduction (A,B,C)-Continued

TOP ARGUMENT=STAR'S DECLINATION, δ

SIDE ARGUMENT=STAR'S ZENITH DISTANCE, ζ

[For factor *A* use left-hand argument. For factor *B* use right-hand argument. Factor *C* is on bottom line of next page]

ζ \ δ	77°40′	77°50′	78°	78°10′	78°20′	78°30′	78°40′	78°50′	79°	79°10′	79°20′	79°30′	79°40′	79°50′	80°	δ / ζ
°																°
1	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.10	0.10	0.10	0.10	89
2	.16	.17	.17	.17	.17	.18	.18	.18	.18	.19	.19	.19	.20	.20	.20	88
3	.24	.25	.25	.26	.26	.26	.27	.27	.27	.28	.28	.29	.29	.30	.30	87
4	.33	.33	.34	.34	.34	.35	.36	.36	.37	.37	.38	.38	.39	.40	.40	86
5	.41	.41	.42	.42	.43	.44	.44	.45	.46	.46	.47	.48	.49	.49	.50	85
6	.49	.50	.51	.51	.52	.52	.53	.54	.55	.56	.56	.57	.58	.59	.60	84
7	.57	.58	.59	.59	.60	.61	.62	.63	.64	.65	.66	.67	.68	.69	.70	83
8	.65	.66	.67	.68	.69	.70	.71	.72	.73	.74	.75	.76	.78	.79	.80	82
9	.73	.74	.75	.76	.77	.78	.80	.81	.82	.83	.84	.86	.87	.89	.90	81
10	.81	.82	.84	.85	.86	.87	.88	.90	.91	.92	.94	.95	.97	.98	1.00	80
11	.89	.90	.92	.93	.94	.96	.97	.98	1.00	1.02	1.03	1.05	1.06	1.08	1.10	79
12	.97	.99	1.00	1.01	1.03	1.04	1.06	1.07	1.09	1.11	1.12	1.14	1.16	1.18	1.20	78
13	1.05	1.07	1.08	1.10	1.11	1.13	1.14	1.16	1.18	1.20	1.22	1.23	1.25	1.27	1.30	77
14	1.13	1.15	1.16	1.18	1.20	1.21	1.23	1.25	1.27	1.29	1.31	1.33	1.35	1.37	1.39	76
15	1.21	1.23	1.25	1.26	1.28	1.30	1.32	1.34	1.36	1.38	1.40	1.42	1.44	1.47	1.49	75
16	1.29	1.31	1.33	1.34	1.36	1.38	1.40	1.42	1.44	1.47	1.49	1.51	1.54	1.56	1.59	74
17	1.37	1.39	1.41	1.43	1.45	1.47	1.49	1.51	1.53	1.56	1.58	1.60	1.63	1.66	1.68	73
18	1.45	1.47	1.49	1.51	1.53	1.55	1.57	1.60	1.62	1.64	1.67	1.70	1.72	1.75	1.78	72
19	1.52	1.54	1.57	1.59	1.61	1.63	1.66	1.68	1.71	1.73	1.76	1.79	1.82	1.84	1.87	71
20	1.60	1.62	1.65	1.67	1.69	1.72	1.74	1.77	1.79	1.82	1.85	1.88	1.91	1.94	1.97	70
21	1.68	1.70	1.72	1.75	1.77	1.80	1.82	1.85	1.88	1.91	1.94	1.97	2.00	2.03	2.06	69
22	1.75	1.78	1.80	1.83	1.85	1.88	1.91	1.93	1.96	1.99	2.02	2.06	2.09	2.12	2.16	68
23	1.83	1.85	1.88	1.90	1.93	1.96	1.99	2.02	2.05	2.08	2.11	2.14	2.18	2.21	2.25	67
24	1.90	1.93	1.96	1.98	2.01	2.04	2.07	2.10	2.13	2.16	2.20	2.23	2.27	2.30	2.34	66
25	1.98	2.00	2.03	2.06	2.09	2.12	2.15	2.18	2.22	2.25	2.28	2.32	2.36	2.39	2.43	65
26	2.05	2.08	2.11	2.14	2.17	2.20	2.23	2.26	2.30	2.33	2.37	2.41	2.44	2.48	2.52	64
27	2.12	2.15	2.18	2.21	2.24	2.28	2.31	2.34	2.38	2.42	2.45	2.49	2.53	2.57	2.61	63
28	2.20	2.23	2.26	2.29	2.32	2.36	2.39	2.42	2.46	2.50	2.54	2.58	2.62	2.66	2.70	62
29	2.27	2.30	2.33	2.36	2.40	2.43	2.47	2.50	2.54	2.58	2.62	2.66	2.70	2.75	2.79	61
30	2.34	2.37	2.40	2.44	2.47	2.51	2.54	2.58	2.62	2.66	2.70	2.74	2.79	2.83	2.88	60
31	2.41	2.44	2.48	2.51	2.55	2.58	2.62	2.66	2.70	2.74	2.78	2.83	2.87	2.92	2.97	59
32	2.48	2.51	2.55	2.58	2.62	2.66	2.70	2.74	2.78	2.82	2.86	2.91	2.95	3.00	3.05	58
33	2.55	2.58	2.62	2.66	2.69	2.73	2.77	2.81	2.85	2.90	2.94	2.99	3.04	3.09	3.14	57
34	2.62	2.65	2.69	2.73	2.76	2.80	2.84	2.89	2.93	2.98	3.02	3.07	3.12	3.17	3.22	56
35	2.68	2.72	2.76	2.80	2.84	2.88	2.92	2.96	3.01	3.05	3.10	3.15	3.20	3.25	3.30	55
36	2.75	2.79	2.83	2.87	2.91	2.95	2.99	3.04	3.08	3.13	3.18	3.23	3.28	3.33	3.38	54
37	2.82	2.86	2.90	2.94	2.98	3.02	3.06	3.11	3.15	3.20	3.25	3.30	3.36	3.41	3.47	53
38	2.88	2.92	2.96	3.00	3.04	3.09	3.13	3.18	3.23	3.28	3.33	3.38	3.43	3.49	3.55	52
39	2.95	2.99	3.03	3.07	3.11	3.16	3.20	3.25	3.30	3.35	3.40	3.45	3.51	3.56	3.62	51
40	3.01	3.05	3.09	3.14	3.18	3.22	3.27	3.32	3.37	3.42	3.47	3.53	3.58	3.64	3.70	50
41	3.07	3.11	3.16	3.20	3.24	3.29	3.34	3.39	3.44	3.49	3.54	3.60	3.66	3.72	3.78	49
42	3.13	3.18	3.22	3.26	3.31	3.36	3.41	3.46	3.51	3.56	3.61	3.67	3.73	3.79	3.85	48
43	3.19	3.24	3.28	3.33	3.37	3.42	3.47	3.52	3.57	3.63	3.68	3.74	3.80	3.86	3.93	47
44	3.25	3.30	3.34	3.39	3.43	3.48	3.54	3.59	3.64	3.70	3.75	3.81	3.87	3.94	4.00	46
45	3.31	3.36	3.40	3.45	3.50	3.55	3.60	3.65	3.71	3.76	3.82	3.88	3.94	4.01	4.07	45
	77°40′	77°50′	78°	78°10′	78°20′	78°30′	78°40′	78°50′	79°	79°10′	79°20′	79°30′	79°40′	79°50′	80°	

Table B-1. Factors For Star Transit Reduction (A,B,C)-Continued

TOP ARGUMENT=STAR'S DECLINATION, δ

SIDE ARGUMENT=STAR'S ZENITH DISTANCE, ζ

[For factor *A* use left-hand argument. For factor *B* use right-hand argument. Factor *C* is on line opposite ζ=90°

ζ \ δ	77° 40′	77° 50′	78°	78° 10′	78° 20′	78° 30′	78° 40′	78° 50′	79°	79° 10′	79° 20′	79° 30′	79° 40′	79° 50′	80°	δ / ζ
°																°
46	3.37	3.41	3.46	3.51	3.56	3.61	3.66	3.71	3.77	3.83	3.89	3.95	4.01	4.08	4.14	44
47	3.42	3.47	3.52	3.57	3.62	3.67	3.72	3.78	3.83	3.89	3.95	4.01	4.08	4.14	4.21	43
48	3.48	3.53	3.57	3.62	3.68	3.73	3.78	3.84	3.89	3.95	4.02	4.08	4.14	4.21	4.28	42
49	3.53	3.58	3.63	3.68	3.73	3.79	3.84	3.90	3.96	4.02	4.08	4.14	4.21	4.28	4.35	41
50	3.59	3.63	3.68	3.74	3.79	3.84	3.90	3.96	4.02	4.08	4.14	4.20	4.27	4.34	4.41	40
51	3.64	3.69	3.74	3.79	3.84	3.90	3.96	4.01	4.07	4.14	4.20	4.26	4.33	4.40	4.48	39
52	3.69	3.74	3.79	3.84	3.90	3.95	4.01	4.07	4.13	4.19	4.26	4.32	4.39	4.46	4.54	38
53	3.74	3.79	3.84	3.89	3.95	4.01	4.06	4.12	4.19	4.25	4.32	4.38	4.45	4.52	4.60	37
54	3.79	3.84	3.89	3.94	4.00	4.06	4.12	4.18	4.24	4.30	4.37	4.44	4.51	4.58	4.66	36
55	3.83	3.89	3.94	3.99	4.05	4.11	4.17	4.23	4.29	4.36	4.43	4.50	4.57	4.64	4.72	35
56	3.88	3.93	3.99	4.04	4.10	4.16	4.22	4.28	4.34	4.41	4.48	4.55	4.62	4.70	4.77	34
57	3.93	3.98	4.04	4.09	4.15	4.21	4.27	4.33	4.39	4.46	4.53	4.60	4.68	4.75	4.83	33
58	3.97	4.02	4.08	4.14	4.19	4.25	4.32	4.38	4.44	4.51	4.58	4.65	4.73	4.80	4.88	32
59	4.01	4.07	4.12	4.18	4.24	4.30	4.36	4.43	4.49	4.56	4.63	4.70	4.78	4.86	4.94	31
60	4.05	4.11	4.17	4.22	4.28	4.34	4.41	4.47	4.54	4.61	4.68	4.75	4.83	4.91	4.99	30
61	4.09	4.15	4.21	4.26	4.32	4.39	4.45	4.52	4.58	4.65	4.72	4.80	4.88	4.96	5.04	29
62	4.13	4.19	4.25	4.31	4.37	4.43	4.49	4.56	4.63	4.70	4.77	4.85	4.92	5.00	5.08	28
63	4.17	4.23	4.29	4.35	4.41	4.47	4.53	4.60	4.67	4.74	4.81	4.89	4.97	5.05	5.13	27
64	4.21	4.26	4.32	4.38	4.44	4.51	4.57	4.64	4.71	4.78	4.86	4.93	5.01	5.09	5.18	26
65	4.24	4.30	4.36	4.42	4.48	4.55	4.61	4.68	4.75	4.82	4.90	4.97	5.05	5.14	5.22	25
66	4.28	4.34	4.40	4.46	4.52	4.58	4.65	4.72	4.79	4.86	4.94	5.01	5.09	5.18	5.26	24
67	4.31	4.37	4.43	4.49	4.55	4.62	4.68	4.75	4.82	4.90	4.97	5.05	5.13	5.22	5.30	23
68	4.34	4.40	4.46	4.52	4.58	4.65	4.72	4.79	4.86	4.93	5.01	5.09	5.17	5.25	5.34	22
69	4.37	4.43	4.49	4.55	4.62	4.68	4.75	4.82	4.89	4.97	5.04	5.12	5.20	5.29	5.38	21
70	4.40	4.46	4.52	4.58	4.65	4.71	4.78	4.85	4.93	5.00	5.08	5.16	5.24	5.32	5.41	20
71	4.43	4.49	4.55	4.61	4.68	4.74	4.81	4.88	4.96	5.03	5.11	5.19	5.27	5.36	5.45	19
72	4.45	4.51	4.57	4.64	4.70	4.77	4.84	4.91	4.98	5.06	5.14	5.22	5.30	5.39	5.48	18
73	4.48	4.54	4.60	4.66	4.73	4.80	4.87	4.94	5.01	5.09	5.17	5.25	5.33	5.42	5.51	17
74	4.50	4.56	4.62	4.69	4.75	4.82	4.89	4.96	5.04	5.11	5.19	5.27	5.36	5.45	5.53	16
75	4.52	4.58	4.65	4.71	4.78	4.85	4.92	4.99	5.06	5.14	5.22	5.30	5.38	5.47	5.56	15
76	4.54	4.60	4.67	4.73	4.80	4.87	4.94	5.01	5.09	5.16	5.24	5.32	5.41	5.50	5.59	14
77	4.56	4.62	4.68	4.75	4.82	4.89	4.96	5.03	5.11	5.18	5.26	5.35	5.43	5.52	5.61	13
78	4.58	4.64	4.70	4.77	4.84	4.91	4.98	5.05	5.13	5.20	5.28	5.37	5.45	5.54	5.63	12
79	4.60	4.66	4.72	4.79	4.85	4.92	5.00	5.07	5.14	5.22	5.30	5.39	5.47	5.56	5.65	11
80	4.61	4.67	4.74	4.80	4.87	4.94	5.01	5.08	5.16	5.24	5.32	5.40	5.49	5.58	5.67	10
81	4.62	4.69	4.75	4.82	4.88	4.95	5.03	5.10	5.18	5.26	5.34	5.42	5.51	5.60	5.69	9
82	4.64	4.70	4.76	4.83	4.90	4.97	5.04	5.11	5.19	5.27	5.35	5.43	5.52	5.61	5.70	8
83	4.65	4.71	4.78	4.84	4.91	4.98	5.05	5.13	5.20	5.28	5.36	5.45	5.53	5.62	5.72	7
84	4.66	4.72	4.79	4.85	4.92	4.99	5.06	5.14	5.21	5.29	5.37	5.46	5.54	5.63	5.73	6
85	4.66	4.73	4.79	4.86	4.93	5.00	5.07	5.14	5.22	5.30	5.38	5.47	5.55	5.64	5.74	5
86	4.67	4.73	4.80	4.86	4.93	5.00	5.08	5.15	5.23	5.31	5.39	5.47	5.56	5.65	5.74	4
87	4.68	4.74	4.81	4.87	4.94	5.01	5.08	5.16	5.23	5.31	5.40	5.48	5.57	5.66	5.75	3
88	4.68	4.74	4.81	4.87	4.94	5.01	5.09	5.16	5.24	5.32	5.40	5.48	5.57	5.66	5.75	2
89	4.68	4.74	4.81	4.88	4.94	5.01	5.09	5.16	5.24	5.32	5.40	5.49	5.57	5.66	5.76	1
90	4.68	4.74	4.81	4.88	4.94	5.02	5.09	5.16	5.24	5.32	5.40	5.49	5.58	5.67	5.76	0
	77° 40′	77° 50′	78°	78° 10′	78° 20′	78° 30′	78° 40′	78° 50′	79°	79° 10′	79° 20′	79° 30′	79° 40′	79° 50′	80°	

Table B-2. Sidereal Gain

[To be added to mean time interval]

1 mean time second=1.00273791 sidereal seconds

minutes / seconds	0	1	2	3	4
0	0.000	0.164	0.329	0.493	0.657
1	.003	.167	.331	.496	.660
2	.005	.170	.334	.498	.663
3	.008	.172	.337	.501	.665
4	.011	.175	.340	.504	.668
5	0.014	0.178	0.342	0.507	0.671
6	.016	.181	.345	.509	.674
7	.019	.183	.348	.512	.676
8	.022	.186	.350	.515	.679
9	.025	.189	.353	.517	.682
10	0.027	0.192	0.356	0.520	0.684
11	.030	.194	.359	.523	.687
12	.033	.197	.361	.526	.690
13	.036	.200	.364	.528	.693
14	.038	.203	.367	.531	.695
15	0.041	0.205	0.370	0.534	0.698
16	.044	.208	.372	.537	.701
17	.047	.211	.375	.539	.704
18	.049	.214	.378	.542	.706
19	.052	.216	.381	.545	.709
20	0.055	0.219	0.383	0.548	0.712
21	.057	.222	.386	.550	.715
22	.060	.225	.389	.553	.717
23	.063	.227	.392	.556	.720
24	.066	.230	.394	.559	.723
25	0.068	0.233	0.397	0.561	0.726
26	.071	.235	.400	.564	.728
27	.074	.238	.402	.567	.731
28	.077	.241	.405	.569	.734
29	.079	.244	.408	.572	.736
30	0.082	0.246	0.411	0.575	0.739
31	.085	.249	.413	.578	.742
32	.088	.252	.416	.580	.745
33	.090	.255	.419	.583	.747
34	.093	.257	.422	.586	.750
35	0.096	0.260	0.424	0.589	0.753
36	.099	.263	.427	.591	.756
37	.101	.266	.430	.594	.758
38	.104	.268	.433	.597	.761
39	.107	.271	.435	.600	.764
40	0.110	0.274	0.438	0.602	0.767
41	.112	.277	.441	.605	.769
42	.115	.279	.444	.608	.772
43	.118	.282	.446	.611	.775
44	.120	.285	.449	.613	.778
45	0.123	0.287	0.452	0.616	0.780
46	.126	.290	.454	.619	.783
47	.129	.293	.457	.622	.786
48	.131	.296	.460	.624	.789
49	.134	.298	.463	.627	.791
50	0.137	0.301	0.465	0.630	0.794
51	.140	.304	.468	.632	.797
52	.142	.307	.471	.635	.799
53	.145	.309	.474	.638	.802
54	.148	.312	.476	.641	.805
55	0.151	0.315	0.479	0.643	0.808
56	.153	.318	.482	.646	.810
57	.156	.320	.485	.649	.813
58	.159	.323	.487	.652	.816
59	.162	.326	.490	.654	.819
60	0.164	0.329	0.493	0.657	0.821

For reducing a series of scaled radio breaks to mean epoch; before mean epoch, add; after mean epoch, subtract.

Table B-3. Mean Refraction, r_m

ζ	0'	1'	2'	3'	4'	5'	6'	7'	8'	9'
00°00'	0″00	″02	″03	″05	″07	″08	″10	″12	″13	″15
10	0.17	.19	.20	.22	.24	.25	.27	.29	.30	.32
20	0.34	.35	.37	.39	.40	.42	.44	.45	.47	.49
30	0.51	.52	.54	.56	.57	.59	.61	.62	.64	.66
40	0.67	.69	.71	.72	.74	.76	.78	.79	.81	.83
00 50	0.84	.86	.88	.89	.91	.93	.94	.96	.98	.99
01 00	1.01	.03	.04	.06	.08	.10	.11	.13	.15	.16
10	1.18	.20	.21	.23	.25	.26	.28	.30	.31	.33
20	1.35	.36	.38	.40	.42	.43	.45	.47	.48	.50
30	1.52	.53	.55	.57	.58	.60	.62	.63	.65	.67
40	1.69	.70	.72	.74	.75	.77	.79	.80	.82	.84
01 50	1.85	.87	.89	.90	.92	.94	.95	.97	1.99	2.01
02 00	2.02	.04	.06	.07	.09	.11	.12	.14	.16	.17
10	2.19	.21	.22	.24	.26	.28	.29	.31	.33	.34
20	2.36	.38	.39	.41	.43	.44	.46	.48	.49	.51
30	2.53	.55	.56	.58	.60	.61	.63	.65	.66	.68
40	2.70	.71	.73	.75	.76	.78	.80	.82	.83	.85
02 50	2.87	.88	.90	.92	.93	.95	.97	2.98	3.00	.02
03 00	3.04	.05	.07	.09	.10	.12	.14	.15	.17	.19
10	3.20	.22	.24	.25	.27	.29	.31	.32	.34	.36
20	3.37	.39	.41	.42	.44	.46	.47	.49	.51	.53
30	3.54	.56	.58	.59	.61	.63	.64	.66	.68	.69
40	3.71	.73	.75	.76	.78	.80	.81	.83	.85	.86
03 50	3.88	.90	.91	.93	.95	.97	3.98	4.00	.02	.03
04 00	4.05	.07	.08	.10	.12	.13	.15	.17	.19	.20
10	4.22	.24	.25	.27	.29	.30	.32	.34	.35	.37
20	4.39	.41	.42	.44	.46	.47	.49	.51	.52	.54
30	4.56	.57	.59	.61	.63	.64	.66	.68	.69	.71
40	4.73	.74	.76	.78	.80	.81	.83	.85	.86	.88
04 50	4.90	.91	.93	.95	.97	4.98	5.00	.02	.03	.05
05 00	5.07	.08	.10	.12	.13	.15	.17	.19	.20	.22
10	5.24	.25	.27	.29	.30	.32	.34	.36	.37	.39
20	5.41	.42	.44	.46	.47	.49	.51	.53	.54	.56
30	5.58	.59	.61	.63	.64	.66	.68	.70	.71	.73
40	5.75	.76	.78	.80	.81	.83	.85	.87	.88	.90
05 50	5.92	.93	.95	.97	5.98	6.00	.02	.04	.05	.07
06 00	6.09	.10	.12	.14	.16	.17	.19	.21	.22	.24
10	6.26	.27	.29	.31	.33	.34	.36	.38	.39	.41
20	6.43	.45	.46	.48	.50	.51	.53	.55	.56	.58
30	6.60	.62	.63	.65	.67	.68	.70	.72	.74	.75
40	6.77	.79	.80	.82	.84	.85	.87	.89	.91	.92
06 50	6.94	.96	.97	6.99	7.01	.03	.04	.06	.08	.09
07 00	7.11	.13	.15	.16	.18	.20	.21	.23	.25	.26
10	7.28	.30	.32	.33	.35	.37	.38	.40	.42	.44
20	7.45	.47	.49	.50	.52	.54	.56	.57	.59	.61
30	7.62	.64	.66	.68	.69	.71	.73	.74	.76	.78
40	7.80	.81	.83	.85	.86	.88	.90	.92	.93	.95
07 50	7.97	7.98	8.00	.02	.04	.05	.07	.09	.10	.12
08 00	8.14	.16	.17	.19	.21	.23	.24	.26	.28	.29
10	8.31	.33	.35	.36	.38	.40	.41	.43	.45	.47
20	8.48	.50	.52	.53	.55	.57	.59	.60	.62	.64
30	8.66	.67	.69	.71	.72	.74	.76	.78	.79	.81
40	8.83	.84	.86	.88	.90	.91	.93	.95	.97	8.98
08 50	9.00	.02	.03	.05	.07	.09	.10	.12	.14	.16
09°00'	9″17									

Table B-3. Mean Refraction, r_m Continued

ζ	0'	1'	2'	3'	4'	5'	6'	7'	8'	9'
09°00'	9"17	"19	"21	"22	"24	"26	"28	"29	"31	"33
10	9.35	.36	.38	.40	.41	.43	.45	.47	.48	.50
20	9.52	.54	.55	.57	.59	.60	.62	.64	.66	.67
30	9.69	.71	.73	.74	.76	.78	.80	.81	.83	.85
40	9.86	.88	.90	.92	.93	.95	.97	9.99	10.00	.02
09 50	10.04	.06	.07	.09	.11	.12	.14	.16	.18	.19
10 00	10.21	.23	.25	.26	.28	.30	.32	.33	.35	.37
10	10.39	.40	.42	.44	.46	.47	.49	.51	.52	.54
20	10.56	.58	.59	.61	.63	.65	.66	.68	.70	.72
30	10.73	.75	.77	.79	.80	.82	.84	.86	.87	.89
40	10.91	.93	.94	.96	10.98	11.00	.01	.03	.05	.06
10 50	11.08	.10	.12	.13	.15	.17	.19	.20	.22	.24
11 00	11.26	.27	.29	.31	.33	.34	.36	.38	.40	.41
10	11.43	.45	.47	.48	.50	.52	.54	.55	.57	.59
20	11.61	.62	.64	.66	.68	.69	.71	.73	.75	.76
30	11.78	.80	.82	.84	.85	.87	.89	.91	.92	.94
40	11.96	.98	11.99	12.01	.03	.05	.06	.08	.10	.12
11 50	12.13	.15	.17	.19	.20	.22	.24	.26	.27	.29
12 00	12.31	.33	.34	.36	.38	.40	.42	.43	.45	.47
10	12.49	.50	.52	.54	.56	.57	.59	.61	.63	.64
20	12.66	.68	.70	.72	.73	.75	.77	.79	.80	.82
30	12.84	.86	.87	.89	.91	.93	.94	.96	12.98	13.00
40	13.02	.03	.05	.07	.09	.10	.12	.14	.16	.18
12 50	13.19	.21	.23	.25	.26	.28	.30	.32	.33	.35
13 00	13.37	.39	.41	.42	.44	.46	.48	.49	.51	.53
10	13.55	.57	.58	.60	.62	.64	.65	.67	.69	.71
20	13.73	.74	.76	.78	.80	.81	.83	.85	.87	.89
30	13.90	.92	.94	.96	.97	13.99	14.01	.03	.05	.06
40	14.08	.10	.12	.14	.15	.17	.19	.21	.22	.24
13 50	14.26	.28	.30	.31	.33	.35	.37	.39	.40	.42
14 00	14.44	.46	.47	.49	.51	.53	.55	.56	.58	.60
10	14.62	.64	.65	.67	.69	.71	.73	.74	.76	.78
20	14.80	.82	.83	.85	.87	.89	.90	.92	.94	.96
30	14.98	14.99	15.01	.03	.05	.07	.08	.10	.12	.14
40	15.16	.17	.19	.21	.23	.25	.26	.28	.30	.32
14 50	15.34	.35	.37	.39	.41	.43	.44	.46	.48	.50
15 00	15.52	.54	.55	.57	.59	.61	.63	.64	.66	.68
10	15.70	.72	.73	.75	.77	.79	.81	.82	.84	.86
20	15.88	.90	.91	.93	.95	.97	15.99	16.01	.02	.04
30	16.06	.08	.10	.11	.13	.15	.17	.19	.21	.22
40	16.24	.26	.28	.30	.31	.33	.35	.37	.39	.41
15 50	16.42	.44	.46	.48	.50	.51	.53	.55	.57	.59
16 00	16.61	.62	.64	.66	.68	.70	.71	.73	.75	.77
10	16.79	.81	.82	.84	.86	.88	.90	.92	.93	.95
20	16.97	16.99	17.01	.03	.04	.06	.08	.10	.12	.14
30	17.15	.17	.19	.21	.23	.25	.26	.28	.30	.32
40	17.34	.36	.37	.39	.41	.43	.45	.47	.48	.50
16 50	17.52	.54	.56	.58	.59	.61	.63	.65	.67	.69
17 00	17.70	.72	.74	.76	.78	.80	.82	.83	.85	.87
10	17.89	.91	.93	.94	.96	17.98	18.00	.02	.04	.06
20	18.07	.09	.11	.13	.15	.17	.18	.20	.22	.24
30	18.26	.28	.30	.31	.33	.35	.37	.39	.41	.43
40	18.44	.46	.48	.50	.52	.54	.56	.57	.59	.61
17 50	18.63	.65	.67	.69	.70	.72	.74	.76	.78	.80
18°00'	18"82									

Table B-3. Mean Refraction, r_m Continued

ζ	0'	1'	2'	3'	4'	5'	6'	7'	8'	9'
18°00'	18"82	"83	"85	"87	"89	"91	"93	"95	"96	18"98
10	19.00	.02	.04	.06	.08	.10	.11	.13	.15	.17
20	19.19	.21	.23	.24	.26	.28	.30	.32	.34	.36
30	19.38	.39	.41	.43	.45	.47	.49	.51	.53	.54
40	19.56	.58	.60	.62	.64	.66	.68	.69	.71	.73
18 50	19.75	.77	.79	.81	.83	.85	.86	.88	.90	.92
19 00	19.94	.96	19.98	20.00	.01	.03	.05	.07	.09	.11
10	20.13	.15	.17	.18	.20	.22	.24	.26	.28	.30
20	20.32	.34	.35	.37	.39	.41	.43	.45	.47	.49
30	20.51	.52	.54	.56	.58	.60	.62	.64	.66	.68
40	20.70	.71	.73	.75	.77	.79	.81	.83	.85	.87
19 50	20.89	.90	.92	.94	.96	20.98	21.00	.02	.04	.06
20 00	21.08	.10	.11	.13	.15	.17	.19	.21	.23	.25
10	21.27	.29	.31	.32	.34	.36	.38	.40	.42	.44
20	21.46	.48	.50	.52	.54	.55	.57	.59	.61	.63
30	21.65	.67	.69	.71	.73	.75	.77	.78	.80	.82
40	21.84	.86	.88	.90	.92	.94	.96	21.98	22.00	.02
20 50	22.03	.05	.07	.09	.11	.13	.15	.17	.19	.21
21 00	22.23	.25	.27	.29	.31	.32	.34	.36	.38	.40
10	22.42	.44	.46	.48	.50	.52	.54	.56	.58	.60
20	22.62	.63	.65	.67	.69	.71	.73	.75	.77	.79
30	22.81	.83	.85	.87	.89	.91	.93	.95	.97	22.98
40	23.00	.02	.04	.06	.08	.10	.12	.14	.16	.18
21 50	23.20	.22	.24	.26	.28	.30	.32	.34	.36	.38
22 00	23.39	.41	.43	.45	.47	.49	.51	.53	.55	.57
10	23.59	.61	.63	.65	.67	.69	.71	.73	.75	.77
20	23.79	.81	.83	.85	.87	.89	.91	.93	.95	.96
30	23.98	24.00	.02	.04	.06	.08	.10	.12	.14	.16
40	24.18	.20	.22	.24	.26	.28	.30	.32	.34	.36
22 50	24.38	.40	.42	.44	.46	.48	.50	.52	.54	.56
23 00	24.58	.60	.62	.64	.66	.68	.70	.72	.74	.76
10	24.78	.80	.82	.84	.86	.88	.90	.92	.94	.96
20	24.98	25.00	.02	.04	.06	.08	.10	.12	.14	.16
30	25.18	.20	.22	.24	.26	.28	.30	.32	.34	.36
40	25.38	.40	.42	.44	.46	.48	.50	.52	.54	.56
23 50	25.58	.60	.62	.64	.66	.68	.70	.72	.74	.76
24 00	25.78	.80	.82	.84	.86	.88	.90	.92	.94	.96
10	25.98	26.00	.02	.04	.06	.08	.10	.12	.14	.16
20	26.18	.20	.22	.25	.27	.29	.31	.33	.35	.37
30	26.39	.41	.43	.45	.47	.49	.51	.53	.55	.57
40	26.59	.61	.63	.65	.67	.69	.71	.73	.75	.77
24 50	26.80	.82	.84	.86	.88	.90	.92	.94	.96	26.98
25 00	27.00	.02	.04	.06	.08	.10	.12	.14	.16	.18
10	27.20	.23	.25	.27	.29	.31	.33	.35	.37	.39
20	27.41	.43	.45	.47	.49	.51	.53	.56	.58	.60
30	27.62	.64	.66	.68	.70	.72	.74	.76	.78	.80
40	27.82	.84	.87	.89	.91	.93	.95	.97	27.99	28.01
25 50	28.03	.05	.07	.09	.11	.14	.16	.18	.20	.22
26 00	28.24	.26	.28	.30	.32	.34	.36	.39	.41	.43
10	28.45	.47	.49	.51	.53	.55	.57	.59	.62	.64
20	28.66	.68	.70	.72	.74	.76	.78	.80	.83	.85
30	28.87	.89	.91	.93	.95	.97	28.99	29.01	.04	.06
40	29.08	.10	.12	.14	.16	.18	.20	.23	.25	.27
26 50	29.29	.31	.33	.35	.37	.39	.42	.44	.46	.48
27°00'	29"50									

Table B-3. Mean Refraction, r_m Continued

ζ	0'	1'	2'	3'	4'	5'	6'	7'	8'	9'
27°00'	29″50	″52	″54	″56	″59	″61	″63	″65	″67	″69
10	29.71	.73	.76	.78	.80	.82	.84	.86	.88	.90
20	29.93	.95	.97	29.99	30.01	.03	.05	.08	.10	.12
30	30.14	.16	.18	.20	.23	.25	.27	.29	.31	.33
40	30.35	.38	.40	.42	.44	.46	.48	.50	.53	.55
27 50	30.57	.59	.61	.63	.65	.68	.70	.72	.74	.76
28 00	30.78	.81	.83	.85	.87	.89	.91	.94	.96	30.98
10	31.00	.02	.04	.07	.10	.11	.13	.15	.17	.20
20	31.22	.24	.26	.28	.30	.33	.35	.37	.39	.41
30	31.43	.46	.48	.50	.52	.54	.57	.59	.61	.63
40	31.65	.68	.70	.72	.74	.76	.78	.81	.83	.85
28 50	31.87	.89	.92	.94	.96	31.98	32.00	.03	.05	.07
29 00	32.09	.11	.14	.16	.18	.20	.22	.25	.27	.29
10	32.31	.33	.36	.38	.40	.42	.44	.47	.49	.51
20	32.53	.56	.58	.60	.62	.64	.67	.69	.71	.73
30	32.75	.78	.80	.82	.84	.87	.89	.91	.93	.96
40	32.98	33.00	.02	.04	.07	.09	.11	.13	.16	.18
29 50	33.20	.22	.25	.27	.29	.31	.34	.36	.38	.40
30 00	33.42	.45	.47	.49	.51	.54	.56	.58	.60	.63
10	33.64	.67	.69	.72	.74	.76	.78	.81	.83	.85
20	33.87	.90	.92	.94	.97	33.99	34.01	.03	.06	.08
30	34.10	.12	.15	.17	.19	.21	.24	.26	.28	.31
40	34.33	.35	.37	.40	.42	.44	.46	.49	.51	.53
30 50	34.56	.58	.60	.62	.65	.67	.69	.72	.74	.76
31 00	34.78	.81	.83	.85	.88	.90	.92	.95	.97	34.99
10	35.01	.04	.06	.08	.11	.13	.15	.18	.20	.22
20	35.24	.27	.29	.31	.34	.36	.38	.41	.43	.45
30	35.48	.50	.52	.54	.57	.59	.61	.64	.66	.68
40	35.71	.73	.75	.78	.80	.82	.85	.87	.89	.92
31 50	35.94	.96	35.99	36.01	.03	.06	.08	.10	.13	.15
32 00	36.17	.20	.22	.24	.27	.29	.31	.34	.36	.38
10	36.41	.43	.45	.48	.50	.53	.55	.57	.60	.62
20	36.64	.67	.69	.71	.74	.76	.78	.81	.83	.86
30	36.88	.90	.93	.95	36.97	37.00	.02	.04	.07	.09
40	37.12	.14	.16	.19	.21	.23	.26	.28	.31	.33
32 50	37.35	.38	.40	.43	.45	.47	.50	.52	.54	.57
33 00	37.59	.62	.64	.66	.69	.71	.74	.76	.78	.81
10	37.83	.86	.88	.90	.93	.95	37.98	38.00	.02	.05
20	38.07	.10	.12	.15	.17	.19	.22	.24	.27	.29
30	38.31	.34	.36	.39	.41	.44	.46	.48	.51	.53
40	38.56	.58	.61	.63	.65	.68	.70	.73	.75	.78
33 50	38.80	.82	.85	.87	.90	.92	.95	38.97	39.00	.02
34 00	39.04	.07	.09	.12	.14	.17	.19	.22	.24	.26
10	39.29	.31	.34	.36	.39	.41	.44	.46	.49	.51
20	39.54	.56	.58	.61	.63	.66	.68	.71	.73	.76
30	39.78	.81	.83	.86	.88	.91	.93	.96	39.98	40.01
40	40.03	.06	.08	.11	.13	.16	.18	.21	.23	.25
34 50	40.28	.30	.33	.35	.38	.40	.43	.45	.48	.50
35 00	40.53	.56	.58	.61	.63	.66	.68	.71	.73	.76
10	40.78	.81	.83	.86	.88	.91	.93	.96	40.98	41.01
20	41.03	.06	.08	.11	.13	.16	.19	.21	.24	.26
30	41.29	.31	.34	.36	.39	.41	.44	.46	.49	.52
40	41.54	.57	.59	.62	.64	.67	.69	.72	.74	.77
35 50	41.80	.82	.85	.87	.90	.92	.95	41.98	42.00	.03
36°00'	42″05									

Table B-3. Mean Refraction, r_m Continued

ζ	0'	1'	2'	3'	4'	5'	6'	7'	8'	9'
36°00'	42″05	″08	″10	″13	″16	″18	″21	″23	″26	″28
10	42.31	.34	.36	.39	.41	.44	.46	.49	.52	.54
20	42.57	.59	.62	.65	.67	.70	.72	.75	.78	.80
30	42.83	.85	.88	.91	.93	.96	42.98	43.01	.04	.06
40	43.09	.12	.14	.17	.19	.22	.25	.27	.30	.32
36 50	43.35	.38	.40	.43	.46	.48	.51	.53	.56	.59
37 00	43.61	.64	.67	.69	.72	.75	.77	.80	.83	.85
10	43.88	.90	.93	.96	43.98	44.01	.04	.06	.09	.12
20	44.14	.17	.20	.22	.25	.28	.30	.33	.36	.38
30	44.41	.44	.46	.49	.52	.54	.57	.60	.62	.65
40	44.68	.70	.73	.76	.79	.81	.84	.87	.89	.92
37 50	44.95	44.97	45.00	.03	.05	.08	.11	.14	.16	.19
38 00	45.22	.24	.27	.30	.33	.35	.38	.41	.43	.46
10	45.49	.52	.54	.57	.60	.62	.65	.68	.71	.73
20	45.76	.79	.82	.84	.87	.90	.92	.95	45.98	46.01
30	46.03	.06	.09	.12	.14	.17	.20	.23	.25	.28
40	46.31	.34	.36	.39	.42	.45	.48	.50	.53	.56
38 50	46.59	.61	.64	.67	.70	.72	.75	.78	.81	.84
39 00	46.86	.89	.92	.95	46.98	47.00	.03	.06	.09	.11
10	47.14	.17	.20	.23	.25	.28	.31	.34	.37	.39
20	47.42	.45	.48	.51	.54	.56	.59	.62	.65	.68
30	47.70	.73	.76	.79	.82	.85	.87	.90	.93	.96
40	47.99	48.02	.04	.07	.10	.13	.16	.19	.21	.24
39 50	48.27	.30	.33	.36	.39	.41	.44	.47	.50	.53
40 00	48.56	.59	.61	.64	.67	.70	.73	.76	.79	.82
10	48.84	.87	.90	.93	.96	48.99	49.02	.05	.08	.10
20	49.13	.16	.19	.22	.25	.28	.31	.34	.36	.39
30	49.42	.45	.48	.51	.54	.57	.60	.63	.66	.69
40	49.71	.74	.77	.80	.83	.86	.89	.92	.95	49.98
40 50	50.01	.04	.07	.10	.12	.15	.18	.21	.24	.27
41 00	50.30	.33	.36	.39	.42	.45	.48	.51	.54	.57
10	50.60	.63	.66	.69	.72	.75	.78	.81	.83	.86
20	50.89	.92	.95	50.98	51.01	.04	.07	.10	.13	.16
30	51.19	.22	.25	.28	.31	.34	.37	.40	.43	.46
40	51.49	.52	.55	.58	.61	.64	.67	.70	.73	.77
41 50	51.80	.83	.86	.89	.92	.95	51.98	52.01	.04	.07
42 00	52.10	.13	.16	.19	.22	.25	.28	.31	.34	.37
10	52.40	.43	.46	.50	.53	.56	.59	.62	.65	.68
20	52.71	.74	.77	.80	.83	.86	.90	.93	.96	52.99
30	53.02	.05	.08	.11	.14	.17	.20	.24	.27	.30
40	53.33	.36	.39	.42	.45	.48	.52	.55	.58	.61
42 50	53.64	.67	.70	.73	.76	.80	.83	.86	.89	.92
43 00	53.95	53.98	54.02	.05	.08	.11	.14	.17	.20	.24
10	54.27	.30	.33	.36	.39	.43	.46	.49	.52	.55
20	54.58	.62	.65	.68	.71	.74	.78	.81	.84	.87
30	54.90	.93	54.97	55.00	.03	.06	.09	.13	.16	.19
40	55.22	.25	.29	.32	.35	.38	.42	.45	.48	.51
43 50	55.54	.58	.61	.64	.67	.71	.74	.77	.80	.84
44 00	55.87	.90	.93	55.97	56.00	.03	.06	.10	.13	.16
10	56.19	.23	.26	.29	.32	.36	.39	.42	.46	.49
20	56.52	.55	.59	.62	.65	.69	.72	.75	.78	.82
30	56.85	.88	.92	.95	56.98	57.02	.05	.08	.11	.15
40	57.18	.21	.25	.28	.31	.35	.38	.41	.45	.48
44 50	57.51	.55	.58	.61	.65	.68	.71	.75	.78	.82
45°00'	57″85									

Table B-4. Temperature Correction For Refraction. C_T

Temperature		C_T	Temperature		C_T	Temperature		C_T	Temperature		C_T	Temperature		C_T
Fahrenheit	Centigrade		Fahrenheit	Centigrade		Fahrenheit	Centigrade		Fahrenheit	Centigrade		Fahrenheit	Centigrade	
°	°		°	°		°	°		°	°		°	°	
-25	-31.7	1.172	8	-13.3	1.089	41	5.0	1.018	74	23.3	0.955	107	41.7	0.900
-24	-31.1	1.169	9	-12.8	1.087	42	5.6	1.016	75	23.9	0.953	108	42.2	0.899
-23	-30.6	1.166	10	-12.2	1.085	43	6.1	1.014	76	24.4	0.952	109	42.8	0.897
-22	-30.0	1.164	11	-11.7	1.082	44	6.7	1.012	77	25.0	0.950	110	43.3	0.895
-21	-29.4	1.161	12	-11.1	1.080	45	7.2	1.010	78	25.6	0.948	111	43.9	0.894
-20	-28.9	1.158	13	-10.6	1.078	46	7.8	1.008	79	26.1	0.946	112	44.4	0.892
-19	-28.3	1.156	14	-10.0	1.076	47	8.3	1.006	80	26.7	0.945	113	45.0	0.891
-18	-27.8	1.153	15	-9.4	1.073	48	8.9	1.004	81	27.2	0.943	114	45.6	0.890
-17	-27.2	1.151	16	-8.9	1.071	49	9.4	1.002	82	27.8	0.941	115	46.1	0.888
-16	-26.7	1.148	17	-8.3	1.069	50	10.0	1.000	83	28.3	0.939	116	46.7	0.886
-15	-26.1	1.145	18	-7.8	1.067	51	10.6	0.998	84	28.9	0.938	117	47.2	0.885
-14	-25.6	1.143	19	-7.2	1.064	52	11.1	0.996	85	29.4	0.936	118	47.8	0.884
-13	-25.0	1.140	20	-6.7	1.062	53	11.7	0.994	86	30.0	0.934	119	48.3	0.882
-12	-24.4	1.138	21	-6.1	1.060	54	12.2	0.992	87	30.6	0.933	120	48.9	0.881
-11	-23.9	1.135	22	-5.6	1.058	55	12.8	0.990	88	31.1	0.931	121	49.4	0.880
-10	-23.3	1.133	23	-5.0	1.056	56	13.3	0.988	89	31.7	0.929	122	50.0	0.878
-9	-22.8	1.130	24	-4.4	1.054	57	13.9	0.986	90	32.2	0 928	123	50.6	0.877
-8	-22.2	1.128	25	-3.9	1.051	58	14.4	0.985	91	32.8	0.926	124	51.1	0.876
-7	-21.7	1.125	26	-3.3	1.049	59	15.0	0.983	92	33.3	0.924	125	51.7	0.874
-6	-21.1	1.123	27	-2.8	1.047	60	15.6	0.981	93	33.9	0.923	126	52.2	0.873
-5	-20.6	1.120	28	-2.2	1.045	61	16.1	0.979	94	34.4	0.921	127	52.8	0.871
-4	-20.0	1.118	29	-1.7	1.043	62	16.7	0.977	95	35.0	0.919	128	53.3	0.870
-3	-19.4	1.115	30	-1.1	1.041	63	17.2	0.975	96	35.6	0.917	129	53.9	0.868
-2	-18.9	1.113	31	-0.6	1.039	64	17.8	0.973	97	36.1	0.916	130	54.4	0.867
-1	-18.3	1.111	32	0.0	1.036	65	18.3	0.972	98	36.7	0.914			
0	-17.8	1.108	33	+0.6	1.034	66	18.9	0.970	99	37.2	0.912			
+1	-17.2	1.106	34	1.1	1.032	67	19.4	0.968	100	37.8	0.911			
2	-16.7	1.103	35	1.7	1.030	68	20.0	0.966	101	38.3	0.909			
3	-16.1	1.101	36	2.2	1.028	69	20.6	0.964	102	38.9	0.908			
4	-15.6	1.099	37	2.8	1.026	70	21.1	0.962	103	39.4	0.906			
5	-15.0	1.096	38	3.3	1.024	71	21.7	0.961	104	40.0	0.905			
6	-14.4	1.094	39	3.9	1.022	72	22.2	0.959	105	40.6	0.903			
7	-13.9	1.092	40	4.4	1.020	73	22.8	0.957	106	41.1	0.902			

Table B-5. Pressure Correction For Refraction. C_B

Barometer		C_B	Barometer		C_B	Barometer		C_B	Barometer		C_B	Barometer		C_B
Inches	*mm*		*Inches*	*mm*		*Inches*	*mm*		*Inches*	*mm*		*Inches*	*mm*	
20.0	508	0.670	22.4	569	0.749	24.8	630	0.829	27.2	691	0.909	29.6	752	0.989
20.1	511	0.673	22.5	572	0.752	24.9	632	0.832	27.3	693	0.912	29.7	754	0.992
20.2	513	0.676	22.6	574	0.755	25.0	635	0.835	27.4	696	0.916	29.8	757	0.996
20.3	516	0.679	22.7	576	0.759	25.1	637	0.838	27.5	699	0.920	29.9	759	0.999
20.4	518	0.682	22.8	579	0.762	25.2	640	0.842	27.6	701	0.923	30.0	762	1.003
20.5	521	0.685	22.9	582	0.766	25.3	643	0.846	27.7	704	0.926	30.1	765	1.007
20.6	523	0.688	23.0	584	0.770	25.4	645	0.849	27.8	706	0.929	30.2	767	1.010
20.7	526	0.692	23.1	587	0.773	25.5	648	0.853	27.9	709	0.933	30.3	770	1.013
20.8	528	0.696	23.2	589	0.776	25.6	650	0.856	28.0	711	0.936	30.4	772	1.016
20.9	531	0.699	23.3	592	0.779	25.7	653	0.859	28.1	714	0.939	30.5	775	1.020
21.0	533	0.703	23.4	594	0.783	25.8	655	0.862	28.2	716	0.942	30.6	777	1.023
21.1	536	0.706	23.5	597	0.786	25.9	658	0.866	28.3	719	0.946	30.7	780	1.026
21.2	538	0.709	23.6	599	0.789	26.0	660	0.869	28.4	721	0.949	30.8	782	1.029
21.3	541	0.712	23.7	602	0.792	26.1	663	0.872	28.5	724	0.953	30.9	785	1.033
21.4	544	0.716	23.8	605	0.796	26.2	665	0.875	28.6	726	0.956	31.0	787	1.036
21.5	546	0.719	23.9	607	0.799	26.3	668	0.879	28.7	729	0.959			
21.6	549	0.722	24.0	610	0.803	26.4	671	0.882	28.8	732	0.963			
21.7	551	0.725	24.1	612	0.806	26.5	673	0.885	28.9	734	0.966			
21.8	554	0.729	24.2	615	0.809	26.6	676	0.889	29.0	737	0.970			
21.9	556	0.732	24.3	617	0.813	26.7	678	0.892	29.1	739	0.973			
22.0	559	0.735	24.4	620	0.816	26.8	681	0.896	29.2	742	0.976			
22.1	561	0.739	24.5	622	0.820	26.9	683	0.899	29.3	744	0.979			
22.2	564	0.742	24.6	625	0.823	27.0	686	0.902	29.4	747	0.983			
22.3	566	0.746	24.7	627	0.826	27.1	688	0.905	29.5	749	0.986			

Table B-6. Reduction To The Meridian For Latitude, m

Top argument is the stars meridian distance

δ	6^m	7^m	8^m	9^m	10^m	15^m	20^m	22^m	24^m	26^m	28^m	30^m	32^m	34^m	36^m	38^m	40^m	42^m	44^m	46^m	48^m	50^m	52^m	54^m	56^m	58^m	60^m	δ
°	″	″	″	″	″	″	″	″	″	″	″	″	″	″	″	″	″	″	″	″	″	″	″	″	″	″	″	°
1														.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.02	.02	89
2									.01	.01	.01	.01	.01	.01	.01	.01	.02	.02	.02	.02	.02	.02	.03	.03	.03	.03	.03	88
3							.01	.01	.01	.01	.01	.01	.01	.02	.02	.02	.02	.03	.03	.03	.03	.04	.04	.04	.04	.05	.05	87
4							.01	.01	.01	.01	.01	.02	.02	.02	.02	.03	.03	.03	.04	.04	.04	.05	.05	.06	.06	.06	.07	86
5						.01	.01	.01	.01	.02	.02	.02	.02	.03	.03	.03	.04	.04	.05	.05	.05	.06	.06	.07	.07	.08	.09	85
6						.01	.01	.01	.02	.02	.02	.03	.03	.03	.04	.04	.05	.05	.06	.06	.07	.07	.08	.08	.09	.10	.10	84
7						.01	.01	.02	.02	.02	.03	.03	.03	.04	.04	.05	.05	.06	.06	.07	.08	.08	.09	.10	.10	.11	.12	83
8						.01	.02	.02	.02	.03	.03	.03	.04	.04	.05	.05	.06	.07	.07	.08	.09	.09	.10	.11	.12	.13	.14	82
9						.01	.02	.02	.02	.03	.03	.04	.04	.05	.05	.06	.07	.07	.08	.09	.10	.11	.11	.12	.13	.14	.15	81
10						.01	.02	.02	.03	.03	.04	.04	.05	.05	.06	.07	.07	.08	.09	.10	.11	.12	.13	.14	.15	.16	.17	80
12					.01	.01	.02	.03	.03	.04	.05	.05	.06	.06	.07	.08	.09	.10	.11	.12	.13	.14	.15	.16	.17	.19	.20	78
14				.01	.01	.01	.03	.03	.04	.04	.05	.06	.07	.07	.08	.09	.10	.11	.12	.14	.15	.16	.17	.19	.20	.22	.23	76
16				.01	.01	.02	.03	.03	.04	.05	.06	.07	.07	.08	.09	.10	.12	.13	.14	.15	.17	.18	.20	.21	.23	.24	.26	74
18			.01	.01	.01	.02	.03	.04	.05	.05	.06	.07	.08	.09	.10	.12	.13	.14	.16	.17	.18	.20	.22	.23	.25	.27	.29	72
20			.01	.01	.01	.02	.04	.04	.05	.06	.07	.08	.09	.10	.11	.13	.14	.15	.17	.19	.20	.22	.24	.26	.28	.29	.32	70
22			.01	.01	.01	.02	.04	.05	.05	.06	.07	.09	.10	.11	.12	.14	.15	.17	.18	.20	.22	.24	.26	.28	.30	.32	.34	68
24			.01	.01	.01	.02	.04	.05	.06	.07	.08	.09	.10	.12	.13	.15	.16	.18	.20	.21	.23	.25	.27	.29	.32	.34	.36	66
26			.01	.01	.01	.02	.04	.05	.06	.07	.08	.10	.11	.12	.14	.15	.17	.19	.21	.23	.25	.27	.29	.31	.34	.36	.39	64
28		.01	.01	.01	.01	.03	.05	.05	.07	.08	.09	.10	.12	.13	.15	.16	.18	.20	.22	.24	.26	.28	.31	.33	.35	.38	.41	62
30		.01	.01	.01	.01	.03	.05	.06	.07	.08	.09	.11	.12	.14	.15	.17	.19	.21	.23	.25	.27	.30	.32	.34	.37	.40	.42	60
32		.01	.01	.01	.01	.03	.05	.06	.07	.08	.10	.11	.13	.14	.16	.18	.20	.22	.24	.26	.28	.31	.33	.36	.39	.41	.44	58
34		.01	.01	.01	.01	.03	.05	.06	.07	.09	.10	.11	.13	.15	.16	.18	.20	.22	.24	.27	.29	.32	.34	.37	.40	.42	.45	56
36		.01	.01	.01	.01	.03	.05	.06	.07	.09	.10	.12	.13	.15	.17	.19	.21	.23	.25	.28	.30	.32	.35	.38	.41	.44	.47	54
38	.01	.01	.01	.01	.01	.03	.05	.06	.08	.09	.10	.12	.13	.15	.17	.19	.21	.23	.26	.28	.30	.33	.36	.39	.41	.44	.48	52
40	.01	.01	.01	.01	.01	.03	.05	.07	.08	.09	.11	.12	.14	.16	.17	.19	.21	.24	.26	.28	.31	.34	.36	.39	.42	.45	.48	50
45	.01	.01	.01	.01	.01	.03	.05	.07	.08	.09	.11	.12	.14	.16	.18	.20	.22	.24	.26	.29	.31	.34	.37	.40	.43	.46	.49	45

For Sterneck Method; The observed zenith distance is decreased numerically if the star is near upper transit between the observers zenith and the elevated pole, or, if the star is on the opposite side of the celestial equator. The observed zenith distance is increased numerically if the star is near upper transit between the observers zenith and the celestial equator, or, if the star is near lower transit. The tabular value from the table must be multiplied by 2 for the total correction to be applied to the observed zenith distance.

For Horrebow-Talcott Method; The algebraic sign of the correction has the same sign as the stars declination. **The tabulated value is m/2, therefore the meridian correction to a pair of stars is the sum of the values from this table.**

Table B-7. Values Of $(2\sin^{2}\frac{1}{2}\tau/\sin 1'')$

τ	0^{m}	1^{m}	2^{m}	3^{m}	4^{m}	5^{m}	6^{m}	7^{m}	8^{m}
s	″	″	″	″	″	″	″	″	″
0	0	1.96	7.85	17.67	31.42	49.09	70.68	96.20	125.65
1	0	2.03	7.98	17.87	31.68	49.41	71.07	96.66	126.17
2	0	2.10	8.12	18.07	31.94	49.74	71.47	97.12	126.70
3	0	2.16	8.25	18.27	32.20	50.07	71.86	97.58	127.22
4	.01	2.23	8.39	18.47	32.47	50.40	72.26	98.04	127.75
5	.01	2.31	8.52	18.67	32.74	50.73	72.66	98.50	128.28
6	.02	2.38	8.66	18.87	33.01	51.07	73.06	98.97	128.81
7	.02	2.45	8.80	19.07	33.27	51.40	73.46	99.43	129.34
8	.03	2.52	8.94	19.28	33.54	51.74	73.86	99.90	129.87
9	.04	2.60	9.08	19.48	33.81	52.07	74.26	100.37	130.40
10	.05	2.67	9.22	19.69	34.09	52.41	74.66	100.84	130.94
11	.06	2.75	9.36	19.90	34.36	52.75	75.06	101.31	131.47
12	.08	2.83	9.50	20.11	34.64	53.09	75.47	101.78	132.01
13	.09	2.91	9.64	20.32	34.91	53.43	75.88	102.25	132.55
14	.11	2.99	9.79	20.53	35.19	53.77	76.29	102.72	133.09
15	.12	3.07	9.94	20.74	35.46	54.11	76.69	103.20	133.63
16	.14	3.15	10.09	20.95	35.74	54.46	77.10	103.67	134.17
17	.16	3.23	10.24	21.16	36.02	54.80	77.51	104.15	134.71
18	.18	3.32	10.39	21.38	36.30	55.15	77.93	104.63	135.25
19	.20	3.40	10.54	21.60	36.58	55.50	78.34	105.10	135.80
20	.22	3.49	10.69	21.82	36.87	55.84	78.75	105.58	136.34
21	.24	3.58	10.84	22.03	37.15	56.19	79.16	106.06	136.88
22	.26	3.67	11.00	22.25	37.44	56.55	79.58	106.55	137.43
23	.28	3.76	11.15	22.47	37.72	56.90	80.00	107.03	137.98
24	.31	3.85	11.31	22.70	38.01	57.25	80.42	107.51	138.53
25	.34	3.94	11.47	22.92	38.30	57.60	80.84	107.99	139.08
26	.37	4.03	11.63	23.14	38.59	57.96	81.26	108.48	139.63
27	.40	4.12	11.79	23.37	38.88	58.32	81.68	108.97	140.18
28	.43	4.22	11.95	23.60	39.17	58.68	82.10	109.46	140.74
29	.46	4.32	12.11	23.82	39.46	59.03	82.52	109.95	141.29
30	.49	4.42	12.27	24.05	39.76	59.40	82.95	110.44	141.85
31	.52	4.52	12.43	24.28	40.05	59.75	83.38	110.93	142.40
32	.56	4.62	12.60	24.51	40.35	60.11	83.81	111.43	142.96
33	.59	4.72	12.76	24.74	40.65	60.47	84.23	111.92	143.52
34	.63	4.82	12.93	24.98	40.95	60.84	84.66	112.41	144.08
35	.67	4.92	13.10	25.21	41.25	61.20	85.09	112.90	144.64
36	.71	5.03	13.27	25.45	41.55	61.57	85.52	113.40	145.20
37	.75	5.13	13.44	25.68	41.85	61.94	85.95	113.90	145.76
38	.79	5.24	13.62	25.92	42.15	62.31	86.39	114.40	146.33
39	.83	5.34	13.79	26.16	42.45	62.68	86.82	114.90	146.89
40	.87	5.45	13.96	26.40	42.76	63.05	87.26	115.40	147.46
41	.91	5.56	14.13	26.64	43.06	63.42	87.70	115.90	148.03
42	0.96	5.67	14.31	26.88	43.37	63.79	88.14	116.40	148.60
43	1.01	5.78	14.49	27.12	43.68	64.16	88.57	116.90	149.17
44	1.06	5.90	14.67	27.37	43.99	64.54	89.01	117.41	149.74
45	1.10	6.01	14.85	27.61	44.30	64.91	89.45	117.92	150.31
46	1.15	6.13	15.03	27.86	44.61	65.29	89.89	118.43	150.88
47	1.20	6.24	15.21	28.10	44.92	65.67	90.33	118.94	151.45
48	1.26	6.36	15.39	28.35	45.24	66.05	90.78	119.45	152.03
49	1.31	6.48	15.57	28.60	45.55	66.43	91.23	119.96	152.61
50	1.36	6.60	15.76	28.85	45.87	66.81	91.68	120.47	153.19
51	1.42	6.72	15.95	29.10	46.18	67.19	92.12	120.98	153.77
52	1.48	6.84	16.14	29.36	46.50	67.58	92.57	121.49	154.35
53	1.53	6.96	16.32	29.61	46.82	67.96	93.02	122.01	154.93
54	1.59	7.09	16.51	29.86	47.14	68.35	93.47	122.53	155.51
55	1.65	7.21	16.70	30.12	47.46	68.73	93.92	123.05	156.09
56	1.71	7.34	16.89	30.38	47.79	69.12	94.38	123.57	156.67
57	1.77	7.46	17.08	30.64	48.11	69.51	94.83	124.09	157.25
58	1.83	7.60	17.28	30.90	48.43	69.90	95.29	124.61	157.84
59	1.89	7.72	17.47	31.16	48.76	70.29	95.74	125.13	158.43

Table B-8. Chauvenet's Rejection Factors

Based on Table IX.A for $\Theta(\rho t')$ (Chauvenet's, Practical Astronomy, Vol. II) and $\Theta(\rho t') = \frac{2n-1}{2n}$

n	t'	n	t'
6	2.57	13	3.07
7	2.67	14	3.11
8	2.76	15	3.15
9	2.84	16	3.19
10	2.91	17	3.23
11	2.97	18	3.26
12	3.02	19	3.29
		20	3.32

When $n > 20$, use $t' = 3.5$

Table B-9. Reduction Of Latitude To Sea Level

h	*φ*	5° 85°	10° 80°	15° 75°	20° 70°	25° 65°	30° 60°	35° 55°	40° 50°	45°
Feet	*Meters*	″	″	″	″	″	″	″	″	″
100	30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
200	61	.00	.00	.01	.01	.01	.01	.01	.01	.01
300	91	.00	.01	.01	.01	.01	.01	.01	.02	.02
400	122	.00	.01	.01	.01	.02	.02	.02	.02	.02
500	152	.00	.01	.01	.02	.02	.02	.02	.03	.03
600	183	.01	.01	.02	.02	.02	.03	.03	.03	.03
700	213	.01	.01	.02	.02	.03	.03	.03	.04	.04
800	244	.01	.01	.02	.03	.03	.04	.04	.04	.04
900	274	.01	.02	.02	.03	.04	.04	.04	.05	.05
1000	305	.01	.02	.03	.03	.04	.05	.05	.05	.05
1100	335	.01	.02	.03	.04	.04	.05	.05	.06	.06
1200	366	.01	.02	.03	.04	.05	.05	.06	.06	.06
1300	396	.01	.02	.03	.04	.05	.06	.06	.07	.07
1400	427	.01	.02	.04	.05	.06	.06	.07	.07	.07
1500	457	.01	.03	.04	.05	.06	.07	.07	.08	.08
1600	488	.01	.03	.04	.05	.06	.07	.08	.08	.08
1700	518	.02	.03	.04	.06	.07	.08	.08	.09	.09
1800	549	.02	.03	.05	.06	.07	.08	.09	.09	.09
1900	579	.02	.03	.05	.06	.08	.09	.09	.10	.10
2000	610	.02	.04	.05	.07	.08	.09	.10	.10	.10
2100	640	.02	.04	.05	.07	.08	.09	.10	.11	.11
2200	671	.02	.04	.06	.07	.09	.10	.11	.11	.11
2300	701	.02	.04	.06	.08	.09	.10	.11	.12	.12
2400	732	.02	.04	.06	.08	.10	.11	.12	.12	.13
2500	762	.02	.04	.07	.08	.10	.11	.12	.13	.13
2600	792	.02	.05	.07	.09	.10	.12	.13	.13	.14
2700	823	.02	.05	.07	.09	.11	.12	.13	.14	.14
2800	853	.03	.05	.07	.09	.11	.13	.14	.14	.15
2900	884	.03	.05	.08	.10	.12	.13	.14	.15	.15
3000	914	.03	.05	.08	.10	.12	.14	.15	.15	.16
3100	945	.03	.06	.08	.10	.12	.14	.15	.16	.16
3200	975	.03	.06	.08	.11	.13	.14	.16	.16	.17
3300	1006	.03	.06	.09	.11	.13	.15	.16	.17	.17
3400	1036	.03	.06	.09	.11	.14	.15	.17	.17	.18
3500	1067	.03	.06	.09	.12	.14	.16	.17	.18	.18
3600	1097	.03	.06	.09	.12	.14	.16	.18	.18	.19
3700	1128	.03	.07	.10	.12	.15	.17	.18	.19	.19
3800	1158	.03	.07	.10	.13	.15	.17	.19	.20	.20
3900	1189	.04	.07	.10	.13	.16	.18	.19	.20	.20
4000	1219	.04	.07	.10	.13	.16	.18	.20	.21	.21
4100	1250	.04	.07	.11	.14	.16	.19	.20	.21	.21
4200	1280	.04	.07	.11	.14	.17	.19	.21	.22	.22
4300	1311	.04	.08	.11	.14	.17	.19	.21	.22	.22
4400	1341	.04	.08	.11	.15	.18	.20	.2[illegible]	.23	.23
4500	1372	.04	.08	.12	.15	.18	.20	.22	.23	.23
4600	1402	.04	.08	.12	.15	.18	.21	.23	.24	.24
4700	1433	.04	.08	.12	.16	.19	.21	.23	.24	.24
4800	1463	.04	.09	.13	.16	.19	.22	.24	.25	.25
4900	1494	.04	.09	.13	.16	.20	.22	.24	.25	.26
5000	1524	.05	.09	.13	.17	.20	.23	.24	.26	.26
5100	1554	.05	.09	.13	.17	.20	.23	.25	.26	.27
5200	1585	.05	.09	.14	.17	.21	.23	.25	.27	.27
5300	1615	.05	.09	.14	.18	.21	.24	.26	.27	.28
5400	1646	.05	.10	.14	.18	.22	.24	.26	.28	.28
5500	1676	.05	.10	.14	.18	.22	.25	.27	.28	.29
5600	1707	0.05	0.10	0.15	0.19	0.22	0.25	0.27	0.29	0.29
5700	1737	.05	.10	.15	.19	.23	.26	.28	.29	.30
5800	1768	.05	.10	.15	.19	.23	.26	.28	.30	.30
5900	1798	.05	.11	.15	.20	.24	.27	.29	.30	.31
6000	1829	.05	.11	.16	.20	.24	.27	.29	.31	.31
6100	1859	.06	.11	.16	.20	.24	.28	.30	.31	.32
6200	1890	.06	.11	.16	.21	.25	.28	.30	.32	.32
6300	1920	.06	.11	.16	.21	.25	.28	.31	.32	.33
6400	1951	.06	.11	.17	.21	.26	.29	.31	.33	.33
6500	1981	.06	.12	.17	.22	.26	.29	.32	.33	.34
6600	2012	.06	.12	.17	.22	.26	.30	.32	.34	.34
6700	2042	.06	.12	.17	.22	.27	.30	.33	.34	.35
6800	2073	.06	.12	.18	.23	.27	.31	.33	.35	.35
6900	2103	.06	.12	.18	.23	.28	.31	.34	.35	.36
7000	2134	.06	.12	.18	.23	.28	.32	.34	.36	.36
7100	2164	.06	.13	.19	.24	.28	.32	.35	.36	.37
7200	2195	.07	.13	.19	.24	.29	.33	.35	.37	.38
7300	2225	.07	.13	.19	.24	.29	.33	.36	.37	.38
7400	2256	.07	.13	.19	.25	.30	.33	.36	.38	.39
7500	2286	.07	.13	.20	.25	.30	.34	.37	.38	.39

Table B-10. Values of (Δδ) for correction to FK4

δ \ α	00h	01h	02h	03h	04h	05h	06h	07h	08h	09h	10h	11h	12h	13h	14h	15h	16h	17h	18h	19h	20h	21h	22h	23h	24h
+85°	-3	-10	-16	-13	-12	-11	-13	-12	-10	-5	7	12	14	5	-3	3	8	11	8	7	6	3	0	1	-3
84	-2	-9	-14	-11	-10	-9	-10	-9	-7	-2	8	13	13	6	-1	4	9	12	9	8	7	4	1	2	-2
83	-1	-7	-12	-10	-9	-7	-8	-6	-4	1	10	13	13	7	-1	6	10	13	10	8	7	5	2	3	-1
82	-1	-6	-9	-8	-7	-6	-5	-4	-2	3	11	14	12	7	2	7	11	14	12	9	8	6	3	3	-1
81	0	-4	-7	-7	-6	-4	-3	-1	1	6	13	14	12	8	4	9	12	15	13	9	8	7	4	4	0
+80°	1	-3	-5	-5	-4	-2	0	2	4	9	14	15	11	9	6	10	13	16	14	10	9	8	5	5	1
79	2	-2	-4	-4	-3	-1	1	4	5	10	14	15	11	10	8	11	14	17	15	11	10	9	6	6	2
78	4	-0	-2	-3	-2	0	3	5	7	11	15	15	12	11	9	13	16	18	16	13	12	10	8	7	4
77	5	1	-1	-1	-0	2	4	7	8	13	15	16	12	13	11	14	17	20	18	14	13	12	9	9	5
76	7	3	1	-0	1	3	6	8	10	14	16	16	13	14	12	16	19	21	19	16	15	13	11	10	7
+75°	8	4	2	1	2	4	7	10	11	15	16	16	13	15	14	17	20	22	20	17	16	14	12	11	8
74	8	4	2	1	1	4	7	10	11	14	15	15	12	14	14	17	20	21	20	17	16	14	12	11	8
73	7	4	2	0	1	3	6	10	11	14	13	13	11	14	14	17	19	21	19	16	15	13	11	10	7
72	7	3	1	-0	0	3	6	9	10	13	12	12	9	13	13	16	19	20	19	16	15	13	11	10	7
71	6	3	1	-1	-0	2	5	9	10	13	10	10	8	13	13	16	18	20	18	15	14	12	10	9	6
+70°	6	3	1	-1	-1	2	5	9	10	12	9	9	7	12	13	16	18	19	18	15	14	12	10	9	6
69	6	3	1	-1	-1	2	5	9	10	11	9	9	7	12	13	16	18	19	18	16	15	13	10	9	6
68	6	3	1	-1	-1	2	5	8	9	11	8	8	7	12	14	17	19	20	19	17	15	13	11	9	6
67	6	3	1	-2	-2	1	4	8	9	10	8	8	7	12	14	17	19	20	19	17	16	14	11	9	6
66	6	3	1	-2	-2	1	4	7	8	10	7	7	7	12	15	18	20	21	20	18	16	14	12	9	6
+65°	6	3	1	-2	-2	1	4	7	8	9	7	7	7	12	15	18	20	21	20	19	17	15	12	9	6
64	6	3	1	-1	-1	1	4	7	8	9	7	7	7	12	16	19	21	22	21	20	18	16	13	10	6
63	7	4	2	-1	-1	1	4	7	8	9	7	7	8	13	17	20	22	23	22	21	19	17	14	10	7
62	7	4	2	-0	-0	2	5	8	8	8	7	8	8	13	18	21	23	23	22	23	21	18	14	11	7
61	8	5	3	0	0	2	5	8	8	8	7	8	9	14	19	22	24	24	23	24	22	19	15	11	8
+60°	8	5	3	1	1	2	5	8	8	8	7	8	9	14	20	23	25	25	24	25	23	20	16	12	8
59	9	6	4	2	2	3	6	8	9	9	8	9	10	15	21	24	26	26	25	26	23	20	16	12	9
58	9	6	5	3	3	4	7	9	9	10	9	10	11	16	22	25	27	27	26	26	24	21	17	13	9
57	10	7	5	4	4	4	7	9	10	10	10	10	12	17	23	27	28	28	26	27	24	21	17	13	10
56	10	7	6	5	5	5	8	10	10	11	11	11	13	18	24	28	29	29	27	27	25	22	18	14	10
+55°	11	8	7	6	6	6	9	10	11	12	12	12	14	19	25	29	30	30	28	28	25	22	18	14	11
54	12	9	8	7	7	7	10	10	11	13	13	13	15	20	26	30	31	31	29	28	25	22	18	14	12
53	12	9	9	8	8	8	10	10	12	13	14	14	16	21	27	31	32	32	30	29	26	23	19	15	12
52	13	10	9	8	8	8	11	11	12	14	14	14	17	21	27	32	33	32	30	29	26	23	19	15	13
51	13	10	10	9	9	9	11	11	13	14	15	15	18	22	28	33	34	33	31	30	27	24	20	16	13
+50°	14	11	11	10	10	10	12	11	13	15	16	16	19	23	29	34	35	34	32	30	27	24	20	16	14

Unity = 0"01

Table B-10. Values of ($\Delta\delta$) for correction to FK4 Continued

α δ	00h	01h	02h	03h	04h	05h	06h	07h	08h	09h	10h	11h	12h	13h	14h	15h	16h	17h	18h	19h	20h	21h	22h	23h	24h
+50°	14	11	11	10	10	10	12	11	13	15	16	16	19	23	29	34	35	34	32	30	27	24	20	16	14
49	14	11	11	10	10	10	12	11	13	15	16	16	19	23	29	34	35	34	32	29	26	24	20	16	14
48	14	11	11	10	10	10	11	11	13	15	16	16	19	23	29	34	35	34	32	29	26	23	20	16	14
47	14	11	10	9	10	10	11	10	12	14	16	16	19	22	28	33	35	34	31	28	25	23	20	17	14
46	14	11	10	9	10	10	10	10	12	14	16	16	19	22	28	33	35	34	31	28	25	22	20	17	14
+45°	14	11	10	9	10	10	10	10	12	14	16	16	19	22	28	33	35	34	31	27	24	22	20	17	14
44	14	11	10	9	10	10	10	10	12	14	16	16	19	22	28	33	35	34	31	27	24	22	20	17	14
43	14	11	10	9	10	10	10	10	12	14	16	16	19	22	28	33	35	34	31	26	23	21	20	17	14
42	14	12	9	9	10	10	9	9	12	14	17	16	19	22	27	33	35	35	31	26	23	21	20	18	14
41	14	12	9	9	10	10	9	9	12	14	17	16	19	22	27	33	35	35	31	25	22	20	20	18	14
+40°	14	12	9	9	10	10	9	9	12	14	17	16	19	22	27	33	35	35	31	25	22	20	20	18	14
39	14	12	9	9	10	10	9	9	12	14	17	16	19	22	27	33	35	35	31	25	22	20	20	18	14
38	14	12	9	9	10	10	9	9	12	13	17	16	19	22	27	33	35	35	31	25	22	20	20	19	14
37	15	13	9	10	10	10	8	8	11	13	16	15	18	21	27	32	35	34	30	25	22	20	21	19	15
36	15	13	9	10	10	10	8	8	11	12	16	15	18	21	27	32	35	34	30	25	22	20	21	20	15
+35°	15	13	9	10	10	10	8	8	11	12	16	15	18	21	27	32	35	34	30	25	22	20	21	20	15
34	15	13	9	10	10	10	8	8	11	12	16	15	18	21	27	32	35	34	30	25	22	20	21	20	15
33	15	13	9	10	10	10	8	7	10	11	15	15	18	21	27	32	35	34	30	25	22	20	21	20	15
32	16	13	9	10	10	10	7	7	10	11	15	14	17	20	26	31	34	33	29	25	21	19	21	21	16
31	16	13	9	10	10	10	7	6	9	10	14	14	17	20	26	31	34	33	29	25	21	19	21	21	16
+30°	16	13	9	10	10	10	7	6	9	10	14	14	17	20	26	31	34	33	29	25	21	19	21	21	16
29	16	13	9	10	10	10	7	6	9	10	13	14	17	20	26	31	34	33	29	25	21	19	20	20	16
28	16	13	9	10	9	9	6	6	8	9	13	13	17	20	26	31	33	32	28	25	21	19	20	20	16
27	15	12	9	9	9	9	6	5	8	9	12	13	16	20	25	30	33	32	28	24	20	18	19	19	15
26	15	12	9	9	8	8	5	5	7	8	12	12	16	20	25	30	32	31	27	24	20	18	19	19	15
+25°	15	12	9	9	8	8	5	5	7	8	11	12	16	20	25	30	32	31	27	24	20	18	18	18	15
24	16	13	10	10	8	8	6	6	7	9	11	13	17	21	26	31	33	31	28	25	21	19	18	18	16
23	16	14	11	10	9	9	6	6	8	9	12	13	18	22	27	32	33	32	28	26	21	19	19	19	16
22	17	14	11	11	9	9	7	7	8	10	12	14	18	22	27	32	34	32	29	26	22	20	19	19	17
21	17	15	12	11	10	10	7	7	9	10	13	14	19	23	28	33	34	33	29	27	22	20	20	20	17
+20°	18	16	13	12	10	10	8	8	9	11	13	15	20	24	29	34	35	33	30	28	23	21	20	20	18
19	18	16	13	12	10	10	9	9	10	12	13	16	21	25	30	35	36	34	31	28	24	22	20	20	18
18	18	16	13	12	11	11	9	9	10	12	14	16	21	26	31	36	37	35	32	29	24	22	21	20	18
17	19	17	14	13	11	11	10	10	11	13	14	17	22	26	31	36	37	35	32	29	25	23	21	21	19
16	19	17	14	13	12	12	10	10	11	13	15	17	22	27	32	37	38	36	33	30	25	23	22	21	19
+15°	19	17	14	13	12	12	11	11	12	14	15	18	23	28	33	38	39	37	34	30	26	24	22	21	19

Unity = 0".01

Table B-10. Values of (Δδ) for correction to FK4 Continued

δ \ α	00^h	01^h	02^h	03^h	04^h	05^h	06^h	07^h	08^h	09^h	10^h	11^h	12^h	13^h	14^h	15^h	16^h	17^h	18^h	19^h	20^h	21^h	22^h	23^h	24^h
+15°	19	17	14	13	12	12	11	11	12	14	15	18	23	28	33	38	39	37	34	30	26	24	22	21	19
14	18	16	13	12	11	11	11	11	12	14	15	18	23	28	33	38	39	37	34	30	26	24	21	20	18
13	17	15	13	12	11	11	11	11	12	13	14	17	22	28	33	38	39	37	34	29	25	24	21	19	17
12	17	15	12	11	10	10	10	10	11	13	14	17	22	27	32	38	39	37	33	29	25	23	20	19	17
11	16	14	12	11	10	10	10	10	11	12	13	16	21	27	32	38	39	37	33	28	24	23	20	18	16
+10°	15	13	11	10	9	9	10	10	11	12	13	16	21	27	32	38	39	37	33	28	24	23	19	17	15
9	14	12	10	9	8	8	9	9	10	11	12	16	21	27	32	37	38	37	33	28	24	23	19	16	14
8	13	11	9	8	7	7	8	9	9	10	12	15	20	26	31	37	38	36	33	28	24	22	18	16	13
7	12	9	8	7	7	7	8	8	9	10	11	15	20	26	31	36	37	36	32	27	23	22	18	15	12
6	11	8	7	6	6	6	7	8	8	9	11	14	19	25	30	36	37	35	32	27	23	21	17	15	11
+5°	10	7	6	5	5	5	6	7	7	8	10	14	19	25	30	35	36	35	32	27	23	21	17	14	10
4	8	5	4	4	4	4	5	6	6	7	9	13	18	24	29	34	35	34	31	26	22	20	16	13	8
3	7	4	3	2	3	2	4	5	5	5	8	12	17	23	28	33	34	33	30	26	22	19	15	12	7
2	5	2	1	1	1	1	2	3	3	4	7	11	17	22	28	31	33	33	30	25	21	18	14	10	5
+1°	4	1	-0	-1	0	-1	1	2	2	2	6	10	16	21	27	30	32	32	29	25	21	17	13	9	4
0	2	-1	-2	-2	-1	-2	0	1	1	1	5	9	15	20	26	29	31	31	28	24	20	16	12	8	2
-1°	2	-2	-3	-3	-2	-3	-1	0	1	1	5	9	15	20	26	29	31	30	27	23	19	16	12	8	2
2	1	-3	-4	-4	-2	-3	-2	-0	0	1	5	9	15	20	25	28	30	29	26	23	19	15	11	7	1
3	1	-3	-5	-5	-3	-4	-2	-1	-0	1	4	9	15	19	25	28	30	29	26	22	18	15	11	7	1
4	0	-4	-6	-6	-3	-4	-3	-1	-1	1	4	9	15	19	24	27	29	28	25	22	18	14	10	6	0
-5°	0	-5	-7	-7	-4	-5	-4	-2	-1	1	4	9	15	19	24	27	29	27	24	21	17	14	10	6	0
6	0	-5	-7	-7	-4	-5	-4	-2	-1	1	4	9	15	19	24	27	29	27	24	21	17	14	10	6	0
7	0	-5	-7	-7	-4	-5	-4	-2	-1	2	5	10	16	20	24	27	29	27	24	21	17	14	10	6	0
8	1	-6	-8	-8	-4	-4	-4	-2	-0	2	5	10	16	20	25	28	29	26	23	20	16	14	11	6	1
9	1	-6	-8	-8	-4	-4	-4	-2	-0	3	6	11	17	21	25	28	29	26	23	20	16	14	11	6	1
-10°	1	-6	-8	-8	-4	-4	-4	-2	0	3	6	11	17	21	25	28	29	26	23	20	16	14	11	6	1
11	1	-6	-8	-9	-5	-4	-4	-2	0	3	6	11	17	21	25	28	29	26	23	20	16	14	11	6	1
12	1	-6	-8	-9	-5	-5	-5	-2	0	4	6	11	17	21	25	28	29	26	23	20	16	15	11	7	1
13	2	-6	-9	-10	-6	-5	-5	-2	1	4	6	11	16	22	26	29	30	27	24	21	17	15	12	7	2
14	2	-6	-9	-10	-6	-6	-6	-2	1	5	6	11	16	22	26	29	30	27	24	21	17	16	12	8	2
-15°	2	-6	-9	-11	-7	-6	-6	-2	1	5	6	11	16	22	26	29	30	27	24	21	17	16	12	8	2
16	2	-5	-9	-11	-7	-6	-6	-2	2	6	6	11	16	22	26	30	31	28	24	21	18	17	13	9	2
17	3	-5	-9	-11	-7	-6	-6	-1	2	6	6	11	16	23	27	30	31	28	25	22	18	17	13	9	3
18	3	-4	-8	-11	-8	-6	-5	-1	3	7	7	12	17	23	27	31	32	29	25	22	19	18	14	10	3
19	4	-4	-8	-11	-8	-6	-5	-0	3	7	7	12	17	24	28	31	32	29	26	23	19	18	14	10	4
-20°	4	-3	-8	-11	-8	-6	-5	0	4	8	7	12	17	24	28	32	33	30	26	23	20	19	15	11	4

Unity = 0".01

Table B-10. Values of (Δδ) for correction to FK4 Continued

δ \ α	00^h	01^h	02^h	03^h	04^h	05^h	06^h	07^h	08^h	09^h	10^h	11^h	12^h	13^h	14^h	15^h	16^h	17^h	18^h	19^h	20^h	21^h	22^h	23^h	24^h
-20°	4	-3	-8	-11	-8	-6	-5	0	4	8	7	12	17	24	28	32	33	30	26	23	20	19	15	11	4
21	5	-1	-6	-9	-7	-4	-3	1	5	9	8	13	18	25	29	33	34	31	27	24	21	20	16	12	5
22	7	1	-4	-8	-5	-3	-2	3	6	10	9	14	19	26	30	34	35	32	28	25	22	21	17	14	7
23	8	2	-3	-6	-4	-1	-0	4	8	11	11	16	20	27	30	34	35	33	29	27	24	23	19	15	8
24	10	4	-1	-5	-2	0	1	6	9	12	12	17	21	28	31	35	36	34	30	28	25	24	20	17	10
-25°	11	6	1	-3	-1	2	3	7	10	13	13	18	22	29	32	36	37	35	31	29	26	25	21	18	11
26	11	6	1	-3	-1	2	3	7	9	12	12	17	21	28	31	35	36	34	30	28	25	24	20	17	11
27	10	6	1	-3	-1	2	3	6	9	11	11	16	20	27	30	34	35	33	29	28	24	23	19	17	10
28	10	6	0	-3	-2	1	2	6	8	10	11	16	20	26	28	33	34	33	29	27	24	23	19	16	10
29	9	6	0	-3	-2	1	2	5	8	9	10	15	19	25	27	32	33	32	28	27	23	22	18	16	9
-30°	9	6	0	-3	-2	1	2	5	7	8	9	14	18	24	26	31	32	31	27	26	22	21	17	15	9
31	9	6	0	-3	-2	1	2	5	7	8	9	13	17	23	25	29	30	29	25	24	20	19	16	14	9
32	9	6	0	-3	-2	2	2	5	6	7	8	13	17	22	24	28	28	27	23	22	18	18	15	14	9
33	9	6	1	-2	-1	2	3	4	6	7	8	12	16	22	22	26	26	25	21	19	16	16	14	13	9
34	9	6	1	-2	-1	3	3	4	5	6	7	12	16	21	21	25	24	23	19	17	14	15	13	13	9
-35°	9	6	1	-2	-1	3	3	4	5	6	7	11	15	20	20	23	22	21	17	15	12	13	12	12	9
36	10	7	3	-0	1	5	5	5	6	7	8	12	16	20	20	23	21	20	16	14	11	13	12	13	10
37	11	9	4	2	3	6	6	6	7	8	9	13	16	21	20	22	20	20	16	13	11	12	12	13	11
38	13	10	6	3	4	8	8	7	8	9	10	13	17	21	20	22	20	19	15	12	10	12	13	14	13
39	14	12	7	5	6	9	9	8	9	10	11	14	17	22	20	21	19	19	15	11	10	11	13	14	14
-40°	15	13	9	7	8	11	11	9	10	11	12	15	18	22	20	21	18	18	14	10	9	11	13	15	15
41	16	14	10	8	9	12	12	10	11	13	14	17	20	24	21	22	19	19	15	11	10	12	14	16	16
42	17	15	12	10	10	13	12	11	13	14	15	19	21	25	23	23	20	20	16	12	11	13	15	17	17
43	19	17	13	11	12	13	13	12	14	16	17	20	23	27	24	23	20	21	17	14	13	14	16	18	19
44	20	18	15	13	13	14	13	13	16	17	18	22	24	28	26	24	21	22	18	15	14	15	17	19	20
-45°	21	19	16	14	14	15	14	14	17	19	20	24	26	30	27	25	22	23	19	16	15	16	18	20	21
46	21	19	16	14	14	15	14	14	17	20	21	25	27	31	27	25	22	23	19	16	15	16	18	20	21
47	21	19	17	15	14	15	13	14	18	21	22	26	28	31	28	25	22	23	19	17	16	16	18	20	21
48	22	20	17	15	15	15	13	14	18	21	22	26	28	32	28	25	21	23	20	17	16	17	19	20	22
49	22	20	18	16	15	15	12	14	19	22	23	27	29	32	29	25	21	23	20	18	17	17	19	20	22
-50°	22	20	18	16	15	15	12	14	19	23	24	28	30	33	29	25	21	23	20	18	17	17	19	20	22
51	21	19	17	15	14	14	11	14	19	23	24	29	31	33	29	25	22	23	20	18	17	17	19	19	21
52	20	18	16	15	14	13	11	13	19	23	24	29	32	33	30	26	22	23	21	19	17	17	18	19	20
53	20	17	16	14	13	13	10	13	18	23	25	30	32	34	30	26	23	24	21	19	18	16	18	18	20
54	19	16	15	14	13	12	10	12	18	23	25	30	33	34	31	27	23	24	22	20	18	16	17	18	19
-55°	18	15	14	13	12	11	9	12	18	23	25	31	34	34	31	27	24	24	22	20	18	16	17	17	18

Unity = 0"01

Table B-10. Values of (Δδ) for correction to FK4 Continued

δ \ α	00^h	01^h	02^h	03^h	04^h	05^h	06^h	07^h	08^h	09^h	10^h	11^h	12^h	13^h	14^h	15^h	16^h	17^h	18^h	19^h	20^h	21^h	22^h	23^h	24^h
-55°	18	15	14	13	12	11	9	12	18	23	25	31	34	34	31	27	24	24	22	20	18	16	17	17	18
56	17	14	13	12	11	10	8	11	17	22	25	31	34	34	31	27	24	24	22	20	18	15	16	16	17
57	16	12	11	11	10	9	7	10	17	22	25	31	35	34	31	27	24	24	22	20	17	14	15	15	16
58	14	11	10	10	8	7	6	10	16	21	24	31	35	33	31	26	25	23	22	19	17	14	14	14	14
59	13	9	8	9	7	6	5	9	16	21	24	31	36	33	31	26	25	23	22	19	16	13	13	13	13
-60°	12	8	7	8	6	5	4	8	15	20	24	31	36	33	31	26	25	23	22	19	16	12	12	12	12
61	11	7	6	7	5	4	3	7	14	19	23	30	35	32	31	26	24	21	20	17	15	11	11	11	11
62	10	6	5	5	4	3	3	6	13	18	22	29	34	31	31	26	23	20	18	16	14	10	9	10	10
63	9	4	4	4	3	2	2	6	12	16	20	27	32	31	30	25	23	18	17	14	12	8	8	8	9
64	8	3	3	2	2	1	2	5	11	15	19	26	31	30	30	25	22	17	15	13	11	7	6	7	8
-65°	7	2	2	1	1	0	1	4	10	14	18	25	30	29	30	25	21	15	13	11	10	6	5	6	7
66	6	1	1	-1	-0	-1	0	3	9	13	17	24	29	28	30	25	20	13	11	9	9	5	4	5	6
67	5	-0	-0	-2	-1	-2	-1	2	8	11	16	22	28	27	29	25	19	11	9	8	7	3	2	4	5
68	3	-2	-2	-4	-3	-3	-1	1	6	10	14	21	26	27	29	24	19	10	8	6	6	2	1	2	3
69	2	-3	-3	-5	-4	-4	-2	0	5	8	13	19	25	26	28	24	18	8	6	5	4	0	-1	1	2
-70°	1	-4	-4	-7	-5	-5	-3	-1	4	7	12	18	24	25	28	24	17	6	4	3	3	-1	-2	0	1
71	1	-4	-4	-7	-5	-5	-3	-1	4	7	12	18	23	24	27	24	16	5	3	2	3	-1	-2	-0	1
72	0	-4	-4	-7	-5	-5	-3	-1	4	7	12	17	22	24	27	24	15	4	2	1	2	-1	-3	-1	0
73	-0	-5	-5	-7	-4	-4	-2	-2	3	7	11	17	21	23	26	23	15	4	2	1	2	-2	-3	-1	-0
74	-1	-5	-5	-7	-4	-4	-2	-2	3	7	11	16	20	23	26	23	14	3	1	-0	1	-2	-4	-2	-1
-75°	-1	-5	-5	-7	-4	-4	-2	-2	3	7	11	16	19	22	25	23	13	2	0	-1	1	-2	-4	-2	-1
76	-1	-4	-5	-6	-3	-3	-1	-1	3	7	11	16	19	22	25	23	13	2	-0	-1	1	-2	-4	-2	-1
77	-1	-4	-4	-6	-2	-2	-0	-1	3	8	11	16	18	22	25	23	13	2	-0	-1	1	-1	-3	-1	-1
78	-0	-3	-4	-5	-2	-1	0	-0	4	8	12	17	18	21	25	24	12	1	-1	-1	2	-1	-3	-1	-0
79	-0	-3	-3	-5	-1	-0	1	0	4	9	12	17	17	21	25	24	12	1	-1	-1	2	-0	-2	-0	-0
-80°	0	-2	-3	-4	0	1	2	1	4	9	12	17	17	21	25	24	12	1	-1	-1	2	0	-2	0	0
81	-0	-3	-3	-2	2	3	4	3	5	10	13	18	18	21	23	22	12	3	1	1	3	1	-1	1	-0
82	-1	-3	-4	-1	4	5	6	4	6	10	15	19	19	20	21	20	12	5	4	3	4	2	0	1	-1
83	-1	-4	-4	1	5	8	7	6	6	11	16	20	20	20	20	18	12	7	6	5	5	3	2	2	-1
84	-2	-4	-5	2	7	10	9	7	7	11	18	21	21	19	18	16	12	9	9	7	6	4	3	2	-2
-85°	-2	-5	-5	4	9	12	11	9	8	12	19	22	22	19	16	14	12	11	11	9	7	5	4	3	-2

Unity = 0".01

Table B-11. Values of (Δμ') for correction to FK4

δ \ α	00h	01h	02h	03h	04h	05h	06h	07h	08h	09h	10h	11h	12h	13h	14h	15h	16h	17h	18h	19h	20h	21h	22h	23h	24h
+85°	5	-10	-26	-19	-16	-20	-20	-21	-18	-9	12	19	18	-1	-15	-5	4	5	-8	-19	-11	-4	-1	10	5
84	6	-8	-21	-16	-13	-17	-16	-17	-14	-6	13	18	16	-0	-12	-2	6	7	-4	-15	-8	-1	1	11	6
83	7	-5	-17	-13	-11	-13	-12	-13	-11	-3	14	18	14	1	-9	1	8	9	-1	-10	-5	1	3	12	7
82	9	-3	-12	-10	-8	-10	-8	-10	-7	1	14	17	11	1	-6	3	10	12	3	-6	-1	4	6	12	9
81	10	-0	-8	-7	-6	-6	-4	-6	-4	4	15	17	9	2	-3	6	12	14	6	-1	2	6	8	13	10
+80°	11	2	-3	-4	-3	-3	0	-2	0	7	16	16	7	3	0	9	14	16	10	3	5	9	10	14	11
79	13	4	-1	-2	-2	-1	2	0	2	9	16	16	8	5	2	11	16	18	13	6	8	11	12	16	13
78	15	7	2	-0	-0	1	4	3	4	11	16	16	8	6	5	13	18	20	15	9	10	14	15	18	15
77	17	9	4	2	1	3	5	5	7	12	17	17	9	8	7	16	21	23	18	11	13	16	17	20	17
76	19	12	7	4	3	5	7	8	9	14	17	17	9	9	10	18	23	25	20	14	15	19	20	22	19
+75	21	14	9	6	4	7	9	10	11	16	17	17	10	11	12	20	25	27	23	17	18	21	22	24	21
74	20	14	9	5	3	6	8	10	11	15	15	14	8	10	12	19	24	27	23	17	18	21	22	23	20
73	20	13	8	4	2	6	7	10	10	14	12	12	6	9	12	19	24	26	23	17	18	20	21	23	20
72	19	13	8	4	0	5	7	9	10	13	10	9	3	8	11	18	23	26	22	18	18	20	21	22	19
71	19	12	7	3	-1	5	6	9	9	12	7	7	1	7	11	18	23	25	22	18	18	19	20	22	19
+70°	18	12	7	2	-2	4	5	9	9	11	5	4	-1	6	11	17	22	25	22	18	18	19	20	21	18
69	17	11	6	1	-3	3	4	8	8	10	4	3	-2	5	11	16	21	24	21	18	18	19	19	20	17
68	16	10	5	0	-3	2	3	7	7	9	3	2	-3	4	10	16	20	23	21	18	18	18	18	19	16
67	14	8	4	-1	-4	0	3	7	7	8	3	0	-3	4	10	15	20	22	20	18	18	18	18	17	14
66	13	7	3	-2	-4	-1	2	6	6	7	2	-1	-4	3	9	15	19	21	20	18	18	17	17	16	13
+65°	12	6	2	-3	-5	-2	1	5	5	6	1	-2	-5	2	9	14	18	20	19	18	18	17	16	15	12
64	13	7	3	-2	-3	-1	3	7	6	7	2	-1	-3	4	11	16	19	21	21	20	20	19	18	16	13
63	14	8	5	-0	-1	1	4	8	8	9	4	1	-1	5	13	18	21	23	22	23	23	21	19	17	14
62	15	10	6	1	0	2	6	10	9	10	5	2	0	7	14	19	22	24	24	25	25	23	21	18	15
61	16	11	8	3	2	4	7	11	11	12	7	4	2	8	16	21	24	26	25	28	28	25	22	19	16
+60°	17	12	9	4	4	5	9	13	12	13	8	5	4	10	18	23	25	27	27	30	30	27	24	20	17
59	19	14	11	6	7	8	12	15	14	15	11	8	7	13	20	26	27	29	29	32	32	29	26	22	19
58	21	16	13	9	9	10	14	17	17	18	14	10	10	15	23	28	30	31	31	34	33	30	27	23	21
57	23	19	16	11	12	13	17	20	19	20	16	13	13	18	25	31	32	33	33	35	35	32	29	25	23
56	25	21	18	14	14	15	19	22	22	23	19	15	16	20	28	33	35	35	35	37	36	33	30	26	25
+55°	27	23	20	16	17	18	22	24	24	25	22	18	19	23	30	36	37	37	37	39	38	35	32	28	27
54	29	25	22	18	19	20	24	26	26	27	25	20	22	25	32	38	39	39	39	40	39	36	33	29	29
53	31	27	24	20	21	22	26	28	28	29	27	23	24	28	34	41	41	41	40	42	40	37	34	31	31
52	32	28	25	22	24	25	29	29	31	32	30	25	27	30	37	43	43	42	42	43	42	39	36	32	32
51	34	30	27	24	26	27	31	31	33	34	32	28	29	33	39	46	45	44	43	45	43	40	37	34	34
+50°	36	32	29	26	28	29	33	33	35	36	35	30	32	35	41	48	47	46	45	46	44	41	38	35	36

Unity = 0"01

Table B-11. Values of $(\Delta\mu')$ for correction to FK4 Continued

δ \ α	00h	01h	02h	03h	04h	05h	06h	07h	08h	09h	10h	11h	12h	13h	14h	15h	16h	17h	18h	19h	20h	21h	22h	23h	24h
+50°	36	32	29	26	28	29	33	33	35	36	35	30	32	35	41	48	47	46	45	46	44	41	38	35	36
49	36	32	29	26	28	28	32	32	34	35	34	29	31	34	40	48	47	46	45	45	43	41	38	35	36
48	36	32	28	26	27	28	31	31	32	34	34	29	30	33	40	47	47	46	45	44	43	40	38	35	36
47	35	32	28	25	27	27	30	29	31	33	33	28	30	33	39	47	47	46	44	44	42	40	38	36	35
46	35	32	27	25	26	27	29	28	29	32	33	28	29	32	39	46	47	46	44	43	42	39	38	36	35
+45°	35	32	27	25	26	26	28	27	28	31	32	27	28	31	38	46	47	46	44	42	41	39	38	36	35
44	35	32	27	25	26	25	27	26	27	30	31	26	27	30	37	46	47	46	44	41	40	39	38	36	35
43	34	32	26	24	25	25	26	24	25	29	30	25	26	29	37	45	47	46	43	40	39	38	38	36	34
42	34	32	26	24	25	24	24	23	24	28	30	25	25	28	36	45	47	46	43	40	39	38	38	37	34
41	33	32	25	23	24	24	23	21	22	27	29	24	24	27	36	44	47	46	42	39	38	37	38	37	33
+40°	33	32	25	23	24	23	22	20	21	26	28	23	23	26	35	44	47	46	42	38	37	37	38	37	33
39	34	33	25	24	24	23	22	20	21	25	28	23	23	26	35	44	48	47	43	39	38	38	39	38	34
38	35	33	26	24	25	24	22	20	21	25	27	23	23	26	35	44	48	48	44	40	38	38	40	39	35
37	35	34	26	25	25	24	22	20	20	24	27	22	22	25	35	45	49	48	44	40	39	39	40	40	35
36	36	34	27	25	26	25	22	20	20	24	26	22	22	25	35	45	49	49	45	41	39	39	41	41	36
+35°	37	35	27	26	26	25	22	20	20	23	26	22	22	25	35	45	50	50	46	42	40	40	42	42	37
34	37	34	26	25	25	24	21	19	18	21	24	20	20	24	34	44	49	49	45	42	39	39	42	42	37
33	36	33	25	25	24	23	20	17	17	19	23	19	19	22	33	43	49	49	45	41	39	39	41	42	36
32	36	33	25	24	23	23	18	16	15	18	21	17	17	21	31	41	48	48	44	41	38	38	41	41	36
31	35	32	24	24	22	22	17	14	14	16	20	16	16	19	30	40	48	48	44	40	38	38	40	41	35
+30°	35	31	23	23	21	21	16	13	12	14	18	14	14	18	29	39	47	47	43	40	37	37	40	41	35
29	34	31	23	22	20	20	16	13	12	14	17	13	14	18	29	39	46	46	43	40	36	36	39	40	34
28	34	30	22	22	20	20	15	12	12	13	16	13	14	18	29	38	46	45	42	39	35	35	37	39	34
27	33	30	22	21	19	19	15	12	11	13	15	12	14	18	28	38	45	45	42	39	35	34	36	38	33
26	33	29	21	21	19	19	14	11	11	12	14	12	14	18	28	37	45	44	41	38	34	33	34	37	33
+25°	32	29	21	20	18	18	14	11	11	12	13	11	14	18	28	37	44	43	41	38	33	32	33	36	32
24	32	29	22	20	18	18	14	12	12	12	13	11	15	19	29	38	44	43	41	38	33	32	33	36	32
23	33	30	22	21	18	18	15	12	13	13	13	12	16	20	29	38	44	43	42	39	33	32	32	36	33
22	33	30	23	21	19	19	15	13	13	13	13	12	16	20	30	39	45	44	42	39	34	32	32	35	33
21	34	31	23	22	19	19	16	13	14	14	13	13	17	21	30	39	45	44	43	40	34	32	31	35	34
+20°	34	31	24	22	19	19	16	14	15	14	13	13	18	22	31	40	45	44	43	40	34	32	31	35	34
19	33	30	24	22	19	19	16	14	15	14	13	13	18	23	32	41	46	45	43	40	34	32	31	34	33
18	32	29	23	21	19	19	16	15	16	15	13	14	19	23	33	42	47	46	44	40	34	33	31	34	32
17	31	29	23	21	18	18	17	15	16	15	14	14	19	24	33	42	47	46	44	41	35	33	30	33	31
16	30	28	22	20	18	18	17	16	17	16	14	15	20	24	34	43	48	47	45	41	35	34	30	33	30
+15°	29	27	22	20	18	18	17	16	17	16	14	15	20	25	35	44	49	48	45	41	35	34	30	32	29

Unity = 0"01

Table B-11. Values of $(\Delta\mu')$ for correction to FK4 Continued

δ \ α	00h	01h	02h	03h	04h	05h	06h	07h	08h	09h	10h	11h	12h	13h	14h	15h	16h	17h	18h	19h	20h	21h	22h	23h	24h
+15°	29	27	22	20	18	18	17	16	17	16	14	15	20	25	35	44	49	48	45	41	35	34	30	32	29
14	27	25	20	19	17	17	16	15	16	15	13	14	19	25	35	44	49	48	44	40	34	33	29	30	27
13	25	23	19	17	16	16	15	15	15	14	12	14	19	24	34	43	48	47	43	39	33	32	28	28	25
12	23	21	17	16	14	14	15	14	15	14	12	13	18	24	34	43	48	47	43	38	33	32	26	27	23
11	21	19	16	14	13	13	14	14	14	13	11	13	18	23	33	42	47	46	42	37	32	31	25	25	21
+10°	19	17	14	13	12	12	13	13	13	12	10	12	17	23	33	42	47	46	41	36	31	30	24	23	19
9	17	15	12	11	10	10	11	11	11	10	9	11	16	22	32	41	46	45	40	35	30	29	23	21	17
8	15	13	10	9	8	8	9	10	9	8	8	10	15	21	31	40	45	44	39	34	29	27	21	19	15
7	12	10	7	7	7	7	8	8	7	6	6	9	15	21	31	38	43	43	39	34	28	26	20	18	12
6	10	8	5	5	5	5	6	7	5	4	5	8	14	20	30	37	42	42	38	33	27	24	18	16	10
+5°	8	6	3	3	3	3	4	5	3	2	4	7	13	19	29	36	41	41	37	32	26	23	17	14	8
4	5	3	0	1	1	1	2	3	1	-1	2	5	12	18	28	34	39	40	36	31	25	21	15	12	5
3	3	0	-2	-2	-2	-2	-0	1	-2	-3	0	4	11	17	26	33	38	38	34	29	23	19	13	10	3
2	0	-2	-5	-4	-4	-4	-3	-2	-4	-6	-1	2	9	15	25	31	36	37	33	28	22	18	12	7	0
1	-2	-5	-7	-7	-7	-7	-5	-4	-7	-8	-3	1	8	14	23	30	35	35	31	26	20	16	10	5	-2
0°	-5	-8	-10	-9	-9	-9	-7	-6	-9	-11	-5	-1	7	13	22	28	33	34	30	25	19	14	8	3	-5
-1°	-6	-9	-11	-11	-10	-10	-8	-7	-10	-11	-5	-1	7	13	21	27	32	33	29	23	17	12	7	2	-6
2	-7	-10	-13	-12	-11	-11	-9	-8	-10	-11	-6	-1	7	13	21	27	31	32	27	22	15	11	6	1	-7
3	-8	-12	-14	-14	-13	-12	-11	-9	-11	-12	-6	-1	7	12	20	26	31	30	26	20	14	9	4	-1	-8
4	-9	-13	-16	-15	-14	-13	-12	-10	-11	-12	-7	-1	7	12	20	26	30	29	24	19	12	8	3	-2	-9
-5°	-10	-14	-17	-17	-15	-14	-13	-11	-12	-12	-7	-1	7	12	19	25	29	28	23	17	10	6	2	-3	-10
6	-10	-14	-17	-17	-15	-14	-13	-11	-11	-11	-6	0	8	13	20	25	29	28	23	16	9	6	2	-3	-10
7	-9	-14	-17	-17	-15	-14	-13	-10	-11	-10	-5	2	9	14	20	26	30	28	22	16	9	5	2	-3	-9
8	-9	-14	-17	-18	-15	-13	-13	-10	-10	-8	-4	3	10	14	21	26	30	27	22	15	8	5	1	-3	-9
9	-8	-14	-17	-18	-15	-13	-13	-9	-10	-7	-3	5	11	15	21	27	31	27	21	15	8	4	1	-3	-8
-10°	-8	-14	-17	-18	-15	-13	-13	-9	-9	-6	-2	6	12	16	22	27	31	27	21	14	7	4	1	-3	-8
11	-8	-14	-18	-20	-17	-15	-14	-10	-10	-6	-3	6	12	16	22	27	31	27	21	14	7	4	1	-2	-8
12	-8	-14	-19	-21	-19	-16	-16	-11	-10	-6	-4	6	12	17	22	27	31	27	21	14	7	5	1	-2	-8
13	-8	-15	-20	-23	-20	-18	-17	-11	-11	-7	-4	5	12	17	23	28	31	27	20	14	8	5	2	-1	-8
14	-8	-15	-21	-24	-22	-19	-19	-12	-11	-7	-5	5	12	18	23	28	31	27	20	14	8	6	2	-1	-8
-15°	-8	-15	-22	-26	-24	-21	-20	-13	-12	-7	-6	5	12	18	23	28	31	27	20	14	8	6	2	0	-8
16	-7	-14	-22	-26	-25	-21	-20	-13	-11	-6	-6	6	13	19	24	29	32	28	21	15	9	8	3	2	-7
17	-6	-13	-22	-26	-25	-21	-20	-12	-10	-5	-5	7	14	21	25	30	33	29	22	16	10	9	5	4	-6
18	-4	-12	-21	-27	-26	-22	-20	-12	-10	-4	-5	7	15	22	27	32	34	31	23	18	12	11	6	5	-4
19	-3	-11	-21	-27	-26	-22	-20	-11	-9	-3	-4	8	16	24	28	33	35	32	24	19	13	12	8	7	-3
-20°	-2	-10	-21	-27	-27	-22	-20	-11	-8	-2	-4	9	17	25	29	34	36	33	25	20	14	14	9	9	-2

Unity = 0".01

Table B-11. Values of $(\Delta\mu')$ for correction to FK4 Continued

δ \ α	00h	01h	02h	03h	04h	05h	06h	07h	08h	09h	10h	11h	12h	13h	14h	15h	16h	17h	18h	19h	20h	21h	22h	23h	24h
-20°	-2	-10	-21	-27	-27	-22	-20	-11	-8	-2	-4	9	17	25	29	34	36	33	25	20	14	14	9	9	-2
21	2	-6	-17	-24	-24	-19	-17	-8	-5	0	-1	12	20	28	32	37	39	36	28	24	17	18	13	13	2
22	6	-2	-14	-21	-21	-15	-13	-5	-2	3	2	15	24	32	35	40	41	39	31	27	21	21	16	17	6
23	10	2	-10	-17	-17	-12	-10	-2	0	5	5	19	27	35	37	42	44	42	35	31	24	25	20	20	10
24	14	6	-7	-14	-14	-8	-6	1	3	8	8	22	31	39	40	45	46	45	38	34	28	28	23	24	14
-25°	18	10	-3	-11	-11	-5	-3	4	6	10	11	25	34	42	43	48	49	48	41	38	31	32	27	28	18
26	19	11	-2	-11	-10	-4	-2	4	6	9	11	25	35	42	43	48	49	48	41	39	32	33	28	29	19
27	20	12	-1	-10	-10	-4	-1	4	6	9	11	26	35	43	43	48	49	48	42	39	32	34	28	30	20
28	21	14	-0	-10	-9	-3	-1	5	5	8	12	26	36	43	43	48	48	49	42	40	33	34	29	31	21
29	22	15	1	-9	-9	-3	0	5	5	8	12	27	36	44	43	48	48	49	43	40	33	35	29	32	22
-30°	23	16	2	-9	-8	-2	1	5	5	7	12	27	37	44	43	48	48	49	43	41	34	36	30	33	23
31	22	16	2	-8	-7	-1	1	4	4	6	11	25	35	42	41	45	45	46	40	37	31	34	28	32	22
32	22	15	3	-8	-6	-1	2	4	3	5	10	24	33	41	38	42	41	43	37	34	28	31	27	30	22
33	21	15	3	-7	-6	-0	2	3	3	4	8	22	32	39	36	38	38	39	33	30	26	29	25	29	21
34	21	14	4	-7	-5	0	3	3	2	3	7	21	30	38	33	35	34	36	30	27	23	26	24	27	21
-35°	20	14	4	-6	-4	1	3	2	1	2	6	19	28	36	31	32	31	33	27	23	20	24	22	26	20
36	22	16	7	-3	-0	4	6	4	3	3	7	20	29	37	31	31	30	32	26	22	20	24	23	27	22
37	24	18	10	0	3	7	9	6	4	5	9	21	30	38	31	31	29	31	25	21	19	24	24	28	24
38	25	21	12	4	7	11	12	8	6	6	10	22	30	38	31	30	29	31	25	19	19	25	24	29	25
39	27	23	15	7	10	14	15	10	7	8	12	23	31	39	31	30	28	30	24	18	18	25	25	30	27
-40°	29	25	18	10	14	17	18	12	9	9	13	24	32	40	31	29	27	29	23	17	18	25	26	31	29
41	32	28	22	14	17	20	20	14	12	12	17	28	35	43	34	32	29	32	26	20	21	28	29	33	32
42	35	31	25	18	20	22	22	17	15	16	20	31	39	47	38	35	32	34	29	24	25	31	31	36	35
43	37	35	29	22	24	25	24	19	18	19	24	35	42	50	41	37	34	37	32	27	28	33	34	33	37
44	40	38	32	26	27	27	26	22	21	23	27	38	46	54	45	40	37	39	35	31	32	36	36	41	40
-45°	43	41	36	30	30	30	28	24	24	26	31	42	49	57	48	43	39	42	38	34	35	39	39	43	43
46	44	43	38	32	32	31	28	25	26	28	33	44	51	59	50	44	40	43	39	36	37	40	40	44	44
47	45	44	40	35	34	32	29	26	27	30	35	46	53	61	52	45	41	44	41	38	39	41	41	45	45
48	47	46	43	37	35	34	29	26	29	32	37	49	54	63	53	47	41	45	42	40	41	43	43	45	47
49	48	47	45	40	37	35	30	27	30	34	39	51	56	65	55	48	42	46	44	42	43	44	44	46	48
-50°	49	49	47	42	39	36	30	28	32	36	41	53	58	67	57	49	43	47	45	44	45	45	45	47	49
51	48	48	46	41	38	35	29	27	32	36	41	54	59	67	58	50	45	48	46	45	45	44	44	46	48
52	47	46	45	40	37	34	28	27	32	36	42	55	61	67	59	51	46	49	47	46	45	43	44	45	47
53	47	45	43	40	36	33	27	26	31	36	42	55	62	68	61	53	48	50	49	47	46	43	43	45	47
54	46	43	42	39	35	32	26	26	31	36	43	56	64	68	62	54	49	51	50	48	46	42	43	44	46
-55°	45	42	41	38	34	31	25	25	31	36	43	57	65	68	63	55	51	52	51	49	46	41	42	43	45

Unity = 0".01

Table B-11. Values of $(\Delta\mu')$ for correction to FK4 Continued

δ \ α	00h	01h	02h	03h	04h	05h	06h	07h	08h	09h	10h	11h	12h	13h	14h	15h	16h	17h	18h	19h	20h	21h	22h	23h	24h
-55°	45	42	41	38	34	31	25	25	31	36	43	57	65	68	63	55	51	52	51	49	46	41	42	43	45
56	43	39	39	36	32	29	23	23	30	35	42	57	65	67	63	55	52	52	51	49	45	39	40	41	43
57	41	37	36	34	30	27	21	22	29	34	42	56	65	66	63	55	52	52	51	49	44	37	38	39	41
58	39	34	34	32	27	24	19	20	27	32	41	56	66	65	63	56	53	51	52	48	43	36	37	38	39
59	37	32	31	30	25	22	17	19	26	31	41	55	66	64	63	56	53	51	52	48	42	34	35	36	37
-60°	35	29	29	28	23	20	15	17	25	30	40	55	66	63	63	56	54	51	52	48	41	32	30	32	33
61	33	27	27	26	21	18	14	15	23	28	38	53	64	62	63	56	53	49	49	46	39	30	30	32	33
62	32	25	25	23	19	16	13	13	21	25	36	51	62	61	63	57	53	47	47	44	37	27	28	30	32
63	30	24	24	21	18	15	11	12	19	23	33	48	61	59	62	57	52	45	44	42	35	25	25	29	30
64	29	22	22	18	16	13	10	10	17	20	31	46	59	58	62	58	52	43	42	40	33	22	23	27	29
-65°	27	20	20	16	14	11	9	8	15	18	29	44	57	57	62	58	51	41	39	38	31	20	20	25	27
66	26	19	19	14	13	10	9	7	14	17	28	43	56	57	63	59	51	40	37	37	30	19	18	24	26
67	26	18	18	13	12	9	8	6	13	15	26	41	55	57	64	61	52	39	36	36	29	17	17	23	26
68	25	17	18	11	11	8	8	5	11	14	25	40	54	56	64	62	52	37	34	34	28	16	15	22	25
69	25	16	17	10	10	7	7	4	10	12	23	38	53	56	65	64	53	36	33	33	27	14	14	21	25
-70°	24	15	16	8	9	6	7	3	9	11	22	37	52	56	66	65	53	35	31	32	26	13	12	20	24
71	23	15	16	8	10	7	8	4	10	13	23	38	52	57	67	66	52	34	29	31	25	13	11	19	23
72	22	15	15	8	11	8	9	4	10	14	24	39	52	58	67	66	51	33	28	30	24	12	10	18	22
73	22	15	15	9	11	10	9	5	11	16	26	41	51	58	68	67	51	31	26	30	24	12	9	18	22
74	21	15	14	9	12	11	10	5	11	17	27	42	51	59	68	67	50	30	25	29	23	11	8	17	21
-75°	20	15	14	9	13	12	11	6	12	19	28	43	51	60	69	68	49	29	23	28	22	11	7	16	20
76	18	14	13	8	13	12	11	6	12	20	29	43	50	60	69	68	48	27	21	26	21	10	5	15	18
77	17	14	12	9	13	13	11	6	12	21	29	44	49	60	69	68	46	25	19	25	19	9	4	13	17
78	15	13	10	7	13	13	12	5	11	21	30	44	49	60	69	67	45	24	16	23	18	7	2	12	15
79	14	13	9	7	13	14	12	5	11	22	30	45	48	60	69	67	43	22	14	22	16	6	1	10	14
-80°	12	12	8	6	13	14	12	5	11	23	31	45	47	60	69	67	42	20	12	20	15	5	-1	9	12
81	7	6	2	5	13	16	13	6	11	24	34	47	48	57	62	59	37	19	12	18	13	4	-1	7	7
82	3	-1	-4	3	13	18	14	8	11	25	38	49	49	53	55	51	33	18	12	15	11	3	-2	5	3
83	-2	-7	-10	2	13	19	14	9	11	26	41	50	49	50	48	43	28	17	11	13	8	1	-2	2	-2
84	-6	-14	-16	0	13	21	15	11	11	27	45	52	50	46	41	35	24	16	11	10	6	0	-3	0	-6
-85°	-11	-20	-22	-1	13	23	16	12	11	28	48	54	51	43	34	27	19	15	11	8	4	-1	-3	-2	-11

Unity = 0″.01

Table B-12. Correction For Differential Refraction, $\frac{1}{2}(r-r')$

One-half diff. of zenith distances	Zenith distance							
	0°	10°	20°	25°	30°	35°	40°	45°
′	″	″	″	″	″	″	″	″
0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02
1.0	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03
1.5	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.05
2.0	0.03	0.03	0.04	0.04	0.04	0.05	0.06	0.07
2.5	0.04	0.04	0.05	0.05	0.06	0.06	0.07	0.08
3.0	0.05	0.05	0.06	0.06	0.07	0.08	0.09	0.10
3.5	0.06	0.06	0.07	0.07	0.08	0.09	0.10	0.12
4.0	0.07	0.07	0.08	0.08	0.09	0.10	0.11	0.13
4.5	0.08	0.08	0.09	0.09	0.10	0.11	0.13	0.15
5.0	0.08	0.09	0.10	0.10	0.11	0.13	0.14	0.17
5.5	0.09	0.10	0.10	0.11	0.12	0.14	0.16	0.18
6.0	0.10	0.10	0.11	0.12	0.13	0.15	0.17	0.20
6.5	0.11	0.11	0.12	0.13	0.14	0.16	0.19	0.22
7.0	0.12	0.12	0.13	0.14	0.16	0.18	0.20	0.23
7.5	0.13	0.13	0.14	0.15	0.17	0.19	0.21	0.25
8.0	0.13	0.14	0.15	0.16	0.18	0.20	0.23	0.27
8.5	0.14	0.15	0.16	0.17	0.19	0.21	0.24	0.29
9.0	0.15	0.16	0.17	0.18	0.20	0.23	0.26	0.30
9.5	0.16	0.16	0.18	0.19	0.21	0.24	0.27	0.32
10.0	0.17	0.17	0.19	0.20	0.22	0.25	0.29	0.34
10.5	0.18	0.18	0.20	0.21	0.23	0.26	0.30	0.35
11.0	0.18	0.19	0.21	0.22	0.25	0.28	0.31	0.37
11.5	0.19	0.20	0.22	0.23	0.26	0.29	0.33	0.39
12.0	0.20	0.21	0.23	0.25	0.27	0.30	0.34	0.40
12.5	0.21	0.22	0.24	0.26	0.28	0.31	0.36	0.42
13.0	0.22	0.22	0.25	0.27	0.29	0.33	0.37	0.44
13.5	0.23	0.23	0.26	0.28	0.30	0.34	0.39	0.45
14.0	0.23	0.24	0.27	0.29	0.31	0.35	0.40	0.47
14.5	0.24	0.25	0.28	0.30	0.32	0.36	0.41	0.49
15.0	0.25	0.26	0.29	0.31	0.34	0.38	0.43	0.50
15.5	0.26	0.27	0.29	0.32	0.35	0.39	0.44	0.52
16.0	0.27	0.28	0.30	0.33	0.36	0.40	0.46	0.54
16.5	0.28	0.29	0.31	0.34	0.37	0.41	0.47	0.55
17.0	0.29	0.29	0.32	0.35	0.38	0.43	0.49	0.57
17.5	0.29	0.30	0.33	0.36	0.39	0.44	0.50	0.59
18.0	0.30	0.31	0.34	0.37	0.40	0.45	0.51	0.60
18.5	0.31	0.32	0.35	0.38	0.41	0.46	0.53	0.62
19.0	0.32	0.33	0.36	0.39	0.43	0.48	0.54	0.64
19.5	0.33	0.34	0.37	0.40	0.44	0.49	0.56	0.65
20.0	0.34	0.35	0.38	0.41	0.45	0.50	0.57	0.67

The sign of the correction is the same as that of the micrometer difference

Table B-13. Values Of $(2\sin^4 \frac{1}{2}\tau / \sin 1'')$

t	$\frac{2\sin^4 \frac{1}{2}\tau}{\sin 1''}$	Δ	t	$\frac{2\sin^4 \frac{1}{2}\tau}{\sin 1''}$	Δ
01^m00^s	0.00001		05^m00^s	0.00584	
		+0.00002			+0.00172
01 20	.00003		05 20	.00756	
		4			208
01 40	.00007		05 40	.00964	
		8			247
02 00	.00015		06 00	.01211	
		13			292
02 20	.00028		06 20	.01503	
		19			343
02 40	.00047		06 40	.01846	
		29			398
03 00	.00076		07 00	.02244	
		39			458
03 20	.00115		07 20	.02702	
		54			526
03 40	.00169		07 40	.03228	
		70			599
04 00	.00239		08 00	.03827	
		91			+0.00679
04 20	.00330		08 20	.04506	
		113			
04 40	.00443				
		+0.00141			

Table B-14. Logarithms of (1/1-a)

When *a* is positive:

Log *a*	0	1	2	3	4	5	6	7	8	9	10
9.00	0.045758	5869	5980	6092	6204	6317	6429	6542	6656	6769	6883
8.99	0.044660	4769	4878	4987	5096	5205	5315	5425	5536	5647	5758
98	3591	3697	3803	3909	4016	4122	4229	4337	4444	4552	4660
97	2549	2652	2755	2858	2962	3066	3171	3275	3380	3486	3591
96	1532	1633	1733	1834	1936	2037	2139	2241	2343	2446	2549
95	0.040541	0639	0737	0836	0935	1034	1133	1232	1332	1432	1532
94	0.039575	9670	9766	9862	9959	*0055	*0152	*0249	*0346	*0443	*0541
93	8633	8726	8819	8913	9007	9101	9195	9290	9385	9480	9575
92	7714	7805	7896	7987	8079	8171	8263	8355	8447	8540	8633
91	6818	6907	6996	7085	7174	7263	7353	7443	7433	7624	7714
8.90	0.035944	6031	6118	6204	6291	6379	6466	6554	6642	6730	6818
89	5092	5177	5261	5346	5431	5516	5601	5687	5772	5858	5944
88	4261	4343	4426	4508	4591	4674	4757	4841	4924	5008	5092
87	3451	3531	3611	3692	3772	3853	3934	4016	4097	4179	4261
86	2660	2738	2816	2895	2074	3053	3132	3211	3291	3371	3451
85	0.031888	1965	2041	2118	2195	2272	2349	2426	2504	2582	2660
84	1136	1210	1285	1360	1435	1510	1585	1660	1736	1812	1888
83	0.030402	0474	0547	0620	0693	0766	0840	0914	0987	1061	1136
82	0.029685	9756	9827	9898	9970	*0041	*0113	*0185	*0257	*0329	*0402
81	8987	9056	9125	9194	9264	9334	9404	9474	9544	9615	9685
8.80	0.028305	8372	8440	8508	8576	8644	8712	8780	8849	8918	8987
79	7640	7705	7771	7838	7904	7970	8037	8103	8170	8237	8305
78	6990	7055	7119	7183	7248	7313	7378	7443	7509	7574	7640
77	6357	6420	6482	6545	6608	6672	6735	6799	6862	6926	6990
76	5739	5800	5861	5923	5984	6046	6108	6170	6232	6294	6357
75	0.025136	5195	5255	5315	5375	5435	5496	5556	5617	5678	5739
74	4547	4605	4664	4722	4781	4840	4899	4958	5017	5076	5136
73	3973	4029	4086	4143	4201	4258	4316	4373	4431	4489	4547
72	3412	3467	3523	3579	3635	3691	3747	3803	3859	3916	3973
71	2865	2919	2973	3027	3082	3137	3191	3246	3301	3357	3412
8.70	0.022331	2383	2436	2489	2543	2596	2649	2703	2757	2811	2865
69	1809	1861	1913	1964	2016	2068	2121	2173	2225	2278	2331
68	1301	1351	1401	1452	1503	1553	1604	1655	1707	1758	1809
67	0804	0853	0902	0952	1001	1051	1100	1150	1200	1250	1301
66	0.020319	0367	0415	0463	0512	0560	0609	0657	0706	0755	0804
65	0.019846	9893	9940	9987	*0034	*0081	*0128	*0176	*0223	*0271	*0319
64	9384	9430	9475	9521	9567	9613	9660	9706	9752	9799	9846
63	8933	8978	9022	9067	9112	9157	9202	9247	9293	9338	9384
62	8493	8536	8580	8624	8667	8711	8755	8800	8844	8888	8933
61	8063	8105	8148	8191	8233	8276	8319	8363	8406	8449	8493
8.60	0.017643	7685	7726	7768	7810	7852	7894	7936	7978	8020	8063
59	7233	7274	7315	7355	7396	7437	7478	7519	7560	7602	7643
58	6833	6873	6913	6952	6992	7032	7072	7112	7153	7193	7233
57	6443	6482	6520	6559	6598	6637	6676	6715	6755	6794	6833
56	6062	6099	6137	6175	6213	6251	6289	6328	6366	6404	6443
55	0.015689	5726	5763	5800	5837	5874	5912	5949	5986	6024	6062
54	5326	5362	5398	5434	5470	5507	5543	5579	5616	5653	5689
53	4971	5006	5041	5077	5112	5147	5183	5218	5254	5290	5326
52	4624	4659	4693	4727	4762	4797	4831	4866	4901	4936	4971
51	4286	4319	4353	4387	4420	4454	4488	4522	4556	4590	4624
8.50	0.013955	3988	4021	4054	4087	4120	4153	4186	4219	4253	4286

	Proportional parts				
	111	108	105	102	99
1	11.1	10.8	10.5	10.2	9.9
2	22.2	21.6	21.0	20.4	19.8
3	33.3	32.4	31.5	30.6	29.7
4	44.4	43.2	42.0	40.8	39.6
5	55.5	54.0	52.5	51.0	49.5
6	66.6	64.8	63.0	61.2	59.4
7	77.7	75.6	73.5	71.4	69.3
8	88.8	86.4	84.0	81.6	79.2
9	99.9	97.2	94.5	91.8	89.1
	96	93	90	87	84
1	9.6	9.3	9.0	8.7	8.4
2	19.2	18.6	18.0	17.4	16.8
3	28.8	27.9	27.0	26.1	25.2
4	38.4	37.2	36.0	34.8	33.6
5	48.0	46.5	45.0	43.5	32.0
6	57.6	55.8	54.0	52.2	50.4
7	67.2	65.1	63.0	60.9	58.8
8	76.8	74.4	72.0	69.6	67.2
9	86.4	83.7	81.0	78.3	75.6
	81	78	75	72	69
1	8.1	7.8	7.5	7.2	6.9
2	16.2	15.6	15.0	14.4	13.8
3	24.3	23.4	22.5	21.6	20.7
4	32.4	31.2	30.0	28.8	27.6
5	40.5	39.0	37.5	36.0	34.5
6	48.6	46.8	45.0	43.2	41.4
7	56.7	54.6	52.5	50.4	48.3
8	64.8	62.4	60.0	57.6	55.2
9	72.9	70.2	67.5	64.8	62.1
	66	63	60	57	55
1	6.6	6.3	6.0	5.7	5.5
2	13.2	12.6	12.0	11.4	11.0
3	19.8	18.9	18.0	17.1	16.5
4	26.4	25.2	24.0	22.8	22.0
5	33.0	31.5	30.0	28.5	27.5
6	39.6	37.8	36.0	34.2	33.0
7	46.2	44.1	42.0	39.9	38.5
8	52.8	50.4	48.0	45.6	44.0
9	59.4	56.7	54.0	51.3	49.5
	53	51	49	47	45
1	5.3	5.1	4.9	4.7	4.5
2	10.6	10.2	9.8	9.4	9.0
3	15.9	15.3	14.7	14.1	13.5
4	21.2	20.4	19.6	18.8	18.0
5	26.5	25.5	24.5	23.5	22.5
6	31.8	30.6	29.4	28.2	27.0
7	37.1	35.7	34.3	32.9	31.5
8	42.4	40.8	39.2	37.6	36.0
9	47.7	45.9	44.1	42.3	40.5
	43	41	39	37	35
1	4.3	4.1	3.9	3.7	3.5
2	8.6	8.2	7.8	7.4	7.0
3	12.9	12.3	11.7	11.1	10.5
4	17.2	16.4	15.6	14.8	14.0
5	21.5	20.5	19.5	18.5	17.5
6	25.8	24.6	23.4	22.2	21.0
7	30.1	28.7	27.3	25.9	24.5
8	34.4	32.8	31.2	29.6	28.0
9	38.7	36.9	35.1	33.3	31.5

Table B-14. Logarithms of (1/1-a) Continued

When *a* is positive:

Log *a*	0	1	2	3	4	5	6	7	8	9	10
8.50	0.013955	3988	4021	4054	4087	4120	4153	4186	4219	4253	4286
49	3633	3665	3697	3729	3761	3793	3825	3858	3890	3923	3955
48	3318	3349	3380	3411	3443	3474	3506	3537	3569	3601	3633
47	3010	3040	3071	3101	3132	3163	3194	3225	3256	3287	3318
46	2709	2739	2769	2799	2829	2859	2889	2919	2949	2979	3010
45	0.012416	2445	2474	2503	2532	2562	2591	2621	2650	2080	2709
44	2129	2158	2186	2215	2243	2272.	2300	2329	2358	2387	2416
43	1849	1877	1905	1933	1961	1989	2017	2045	2073	2101	2129
42	1576	1603	1630	1657	1685	1712	1739	1767	1794	1822	1849
41	1309	1335	1362	1388	1415	1442	1468	1495	1522	1549	1576
8.40	0.011048	1074	1100	1126	1152	1178	1204	1230	1256	1283	1309
39	0794	0819	0844	0869	0895	0920	0946	0971	0997	1023	1048
38	0545	0570	0594	0619	0644	0669	0694	0718	0743	0769	0794
37	0302	0326	0350	0374	0399	0423	0447	0472	0496	0520	0545
36	0.010065	0088	0112	0135	0159	0183	0207	0230	0254	0278	0302
35	0.009833	9856	9879	9902	9925	9948	9972	9995	*0018	*0041	*0065
34	9607	9629	9652	9674	9697	9719	9742	9765	9787	9810	9833
33	9386	9408	9430	9452	9474	9496	9518	9540	9562	9584	9607
32	9170	9191	9213	9234	9256	9277	9299	9320	9342	9364	9386
31	8959	8980	9001	9022	9043	9064	9085	9106	9127	9149	9170
8.30	0.008753	8773	8794	8814	8835	8855	8876	8897	8917	8938	8959
29	8552	8572	8592	8612	8632	8652	8672	8692	8712	8733	8753
28	8355	8375	8394	8414	8433	8453	8473	8492	8512	8532	8552
27	8163	8182	8201	8220	8239	8259	8278	8297	8316	8336	8355
26	7976	7994	8013	8031	8050	8069	8088	8106	8125	8144	8163
25	0.007792	7811	7829	7847	7865	7884	7902	7920	7939	7957	7976
24	7614	7631	7649	7667	7685	7702	7720	7738	7756	7774	7792
23	7439	7456	7473	7491	7508	7526	7543	7561	7578	7596	7614
22	7268	7285	7302	7319	7336	7353	7370	7387	7404	7421	7439
21	7101	7118	7134	7151	7167	7184	7201	7218	7234	7251	7268
8.20	0.006938	6954	6971	6987	7003	7019	7036	7052	7068	7085	7101
19	6779	6795	6811	6826	6842	6858	6874	6890	6906	6922	6938
18	6624	6639	6654	6670	6685	6701	6716	6732	6748	6763	6779
17	6472	6487	6502	6517	6532	6547	6562	6578	6593	6608	6624
16	6323	6338	6353	6367	6382	6397	6412	6427	6442	6457	6472
15	0.006178	6193	6207	6221	6236	6250	6265	6279	6294	6309	6323
14	6037	6051	6065	6079	6093	6107	6121	6135	6150	6164	6178
13	5898	5912	5926	5940	5953	5967	5981	5995	6009	6023	6037
12	5763	5777	5790	5803	5817	5830	5844	5857	5871	5885	5898
11	5631	5644	5657	5670	5684	5697	5710	5723	5737	5750	5763
8.10	0.005502	5515	5528	5541	5553	5566	5579	5592	5605	5618	5631
09	5376	5389	5401	5414	5426	5439	5451	5464	5477	5489	5502
08	5253	5265	5277	5290	5302	5314	5327	5339	5351	5364	5376
07	5133	5145	5157	5169	5181	5193	5205	5217	5229	5241	5253
06	5015	5027	5038	5050	5062	5074	5085	5097	5109	5121	5133
05	4900	4912	4923	4935	4946	4957	4969	4980	4992	5004	5015
04	4788	4799	4810	4822	4833	4844	4855	4866	4878	4889	4900
03	4679	4690	4700	4711	4722	4733	4744	4755	4766	4777	4788
02	4572	4582	4593	4603	4614	4625	4636	4646	4657	4668	4679
01	4467	4477	4488	4498	4509	4519	4529	4540	4550	4561	4572
8.00	0.004365	4375	4385	4395	4405	4416	4426	4436	4446	4457	4467

Proportional parts					
	34	33	32	31	30
1	3.4	3.3	3.2	3.1	3.0
2	6.8	6.6	6.4	6.2	6.0
3	10.2	9.9	9.6	9.3	9.0
4	13.6	13.2	12.8	12.4	12.0
5	17.0	16.5	16.0	15.5	15.0
6	20.4	19.8	19.2	18.6	18.0
7	23.8	23.1	22.4	21.7	21.0
8	27.2	26.4	25.6	24.8	24.0
9	30.6	29.7	28.8	27.9	27.0
	29	28	27	26	25
1	2.9	2.8	2.7	2.6	2.5
2	5.8	5.6	5.4	5.2	5.0
3	8.7	8.4	8.1	7.8	7.5
6	11.6	11.2	10.8	10.4	10.0
5	14.5	14.0	13.5	13.0	12.5
6	17.4	16.8	16.2	15.6	15.0
7	20.3	19.6	18.9	18.2	17.5
8	23.2	22.4	21.6	20.8	20.0
9	26.1	25.2	24.3	23.4	22.5
	24	23	22	21	20
1	2.4	2.3	2.2	2.1	2.0
2	4.8	4.6	4.4	4.2	4.0
3	7.2	6.9	6.6	6.3	6.0
4	9.6	9.2	8.8	8.4	8.0
5	12.0	11.5	11.0	10.5	10.0
6	14.4	13.8	13.2	12.6	12.0
7	16.8	16.1	15.4	14.7	14.0
8	19.2	18.4	17.6	16.8	16.0
9	21.6	20.7	19.8	18.9	18.0
	19	18	17	16	15
1	1.9	1.8	1.7	1.6	1.5
2	3.8	3.6	3.4	3.2	3.0
3	5.7	5.4	5.1	4.8	4.5
4	7.6	7.2	6.8	6.4	6.0
5	9.5	9.0	8.5	8.0	7.5
6	11.4	10.8	10.2	9.6	9.0
7	13.3	12.6	11.9	11.2	10.5
8	15.2	14.4	13.6	12.8	12.0
9	17.1	16.2	15.3	14.4	13.5
	14	13	12	11	10
1	1.4	1.3	1.2	1.1	1.0
2	2.8	2.6	2.4	2.2	2.0
3	4.2	3.9	3.6	3.3	3.0
4	5.6	5.2	4.8	4.4	4.0
5	7.0	6.5	6.0	5.5	5.0
6	8.4	7.8	7.2	6.6	6.0
7	9.8	9.1	8.4	7.7	7.0
8	11.2	10.4	9.6	8.8	8.0
9	12.6	11.7	10.8	9.9	9.0

Table B-14. Logarithms of (1/1-a) Continued

When *a* is positive:

Log *a*	0	1	2	3	4	5	6	7	8	9	10
8.00	0.004365	4375	4385	4395	4405	4416	4426	4436	4446	4457	4467
7.99	4265	4275	4285	4295	4305	4315	4325	4335	4345	4355	4365
98	4167	4177	4187	4196	4206	4216	4226	4235	4245	4255	4265
97	4072	4082	4091	4100	4110	4119	4129	4139	4148	4158	4167
96	3979	3988	3997	4007	4016	4025	4035	4044	4053	4063	4072
95	0.003888	3897	3906	3915	3924	3933	3942	3951	3961	3970	3979
94	3799	3808	3817	3826	3834	3843	3852	3861	3870	3879	3888
93	3712	3721	3729	3738	3747	3755	3764	3773	3782	3790	3799
92	3627	3636	3644	3653	3661	3670	3678	3687	3695	3704	3712
91	3545	3553	3561	3569	3577	3586	3594	3602	3611	3619	3627
7.90	0.003463	3472	3480	3488	3496	3504	3512	3520	3528	3536	3545
89	3384	3392	3400	3408	3416	3424	3432	3440	3448	3456	3463
88	3307	3315	3322	3330	3338	3345	3353	3361	3369	3377	3384
87	3231	3239	3246	3254	3261	3269	3277	3284	3292	3299	3307
86	3158	3165	3172	3180	3187	3194	3202	3209	3217	3224	3231
85	0.003086	3093	3100	3107	3114	3121	3129	3136	3143	3150	3158
84	3015	3022	3029	3036	3043	3050	3057	3064	3071	3078	3086
83	2946	2953	2960	2967	2974	2980	2987	2994	3001	3008	3015
82	2879	2886	2892	2899	2906	2912	2919	2926	2933	2939	2946
81	2813	2820	2826	2833	2839	2846	2852	2859	2866	2872	2879
7.80	0.002749	2755	2762	2768	2774	2781	2787	2794	2800	2807	2813
79	2686	2692	2699	2705	2711	2717	2724	2730	2736	2743	2749
78	2625	2631	2637	2643	2649	2655	2661	2668	2674	2680	2686
77	2565	2571	2577	2583	2589	2595	2601	2607	2613	2619	2625
76	2506	2512	2518	2524	2530	2535	2541	2547	2553	2559	2565
75	0.002449	2455	2460	2466	2472	2478	2483	2489	2495	2501	2506
74	2393	2399	2404	2410	2415	2421	2427	2432	2438	2443	2449
73	2339	2344	2349	2355	2360	2366	2371	2377	2382	2388	2393
72	2285	2290	2296	2301	2306	2312	2317	2322	2328	2333	2339
71	2233	2238	2243	2249	2254	2259	2264	2269	2275	2280	2285
7.70	0.002182	2187	2192	2197	2202	2207	2213	2218	2223	2228	2233
69	2132	2137	2142	2147	2152	2157	2162	2167	2172	2177	2182
68	2084	2088	2093	2098	2103	2108	2113	2118	2122	2127	2132
67	2036	2041	2046	2050	2055	2060	2065	2069	2074	2079	2084
66	1990	1994	1999	2003	2008	2013	2017	2022	2027	2031	2036
65	0.001944	1949	1953	1958	1962	1967	1971	1976	1980	1985	1990
64	1900	1904	1909	1913	1918	1922	1926	1931	1935	1940	1944
63	1857	1861	1865	1869	1874	1878	1882	1887	1891	1896	1900
62	1814	1818	1823	1827	1831	1835	1840	1844	1848	1852	1857
61	1773	1777	1781	1785	1789	1793	1798	1802	1806	1810	1814
7.60	0.001732	1736	1740	1744	1748	1753	1757	1761	1765	1769	1773
59	1693	1697	1701	1705	1709	1713	1716	1720	1724	1728	1732
58	1654	1658	1662	1666	1670	1673	1677	1681	1685	1689	1693
57	1617	1620	1624	1628	1632	1635	1639	1643	1647	1650	1654
56	1580	1583	1587	1591	1594	1598	1602	1605	1609	1613	1617
55	0.001544	1547	1551	1554	1558	1562	1565	1569	1572	1576	1580
54	1508	1512	1515	1519	1522	1526	1529	1533	1537	1540	1544
53	1474	1477	1481	1484	1488	1491	1495	1498	1502	1505	1508
52	1440	1444	1447	1450	1454	1457	1461	1464	1467	1471	1474
51	1408	1411	1414	1417	1421	1424	1427	1431	1434	1437	1440
7.50	0.001376	1379	1382	1385	1388	1391	1395	1398	1401	1404	1408

Proportional parts

	11	10
1	1.1	1.0
2	2.2	2.0
3	3.3	3.0
4	4.4	4.0
5	5.5	5.0
6	6.6	6.0
7	7.7	7.0
8	8.8	8.0
9	9.9	9.0

	9	8
1	0.9	0.8
2	1.8	1.6
3	2.7	2.4
4	3.6	3.2
5	4.5	4.0
6	5.4	4.8
7	6.3	5.6
8	7.2	6.4
9	8.1	7.2

	7	6
1	0.7	0.6
2	1.4	1.2
3	2.1	1.8
4	2.8	2.4
5	3.5	3.0
6	4.2	3.6
7	4.9	4.2
8	5.6	4.8
9	6.3	5.4

	5	4
1	0.5	0.4
2	1.0	0.8
3	1.5	1.2
4	2.0	1.6
5	2.5	2.0
6	3.0	2.4
7	3.5	2.8
8	4.0	3.2
9	4.5	3.6

Table B-14. Logarithms of (1/1-a) Continued

When *a* is positive:

Log *a*	0	1	2	3	4	5	6	7	8	9	10
7.50	0.001376	1379	1382	1385	1388	1391	1395	1398	1401	1404	1408
49	1344	1347	1350	1354	1357	1360	1363	1366	1369	1372	1376
48	1314	1317	1320	1323	1326	1329	1332	1335	1338	1341	1344
47	1284	1287	1290	1292	1295	1298	1301	1304	1307	1311	1314
46	1254	1257	1260	1263	1266	1269	1272	1275	1278	1281	1284
45	0.001226	1229	1231	1234	1237	1240	1243	1246	1249	1251	1254
44	1198	1201	1203	1206	1209	1212	1214	1217	1220	1223	1226
43	1170	1173	1176	1179	1181	1184	1187	1190	1192	1195	1198
42	1144	1146	1149	1152	1154	1157	1160	1162	1165	1168	1170
41	1118	1120	1123	1126	1128	1131	1133	1136	1139	1141	1144
7.40	0.001092	1095	1097	1100	1102	1105	1107	1110	1113	1115	1118
39	1067	1070	1072	1075	1077	1080	1082	1085	1087	1090	1092
38	1043	1045	1048	1050	1053	1055	1058	1060	1062	1065	1067
37	1019	1022	1024	1026	1029	1031	1033	1036	1038	1041	1043
36	0996	0998	1001	1003	1005	1008	1010	1012	1015	1017	1019
35	0.000973	0976	0978	0980	0982	0985	0987	0989	0991	0994	0996
34	951	953	956	958	960	962	964	967	969	971	973
33	929	932	934	936	938	940	942	945	947	949	951
32	908	910	913	915	917	919	921	923	925	927	929
31	888	890	892	894	896	898	900	902	904	906	908
7.30	0.000867	869	871	873	875	877	879	882	884	886	888
29	848	850	852	854	855	857	859	861	863	865	867
28	828	830	832	834	836	838	840	842	844	846	848
27	809	811	813	815	817	819	821	823	825	826	828
26	791	793	795	796	798	800	802	804	806	808	809
25	0.000773	775	777	778	780	782	784	786	787	789	791
24	755	757	759	761	762	764	766	768	769	771	773
23	738	740	742	743	745	747	748	750	752	754	755
22	721	723	725	726	728	730	731	733	735	736	738
21	705	707	708	710	711	713	715	716	718	720	721
7.20	0.000689	690	692	694	695	697	698	700	702	703	705
19	673	675	676	678	679	681	683	684	686	687	689
18	658	659	661	662	664	665	667	669	670	672	673
17	643	644	646	647	649	650	652	653	655	656	658
16	628	630	631	633	634	635	637	638	640	641	643
15	0.000614	615	617	618	620	621	622	624	625	627	628
14	600	601	603	604	605	607	608	610	611	612	614
13	586	588	589	590	592	593	594	596	597	599	600
12	573	574	576	577	578	580	581	582	584	585	586
11	560	561	562	564	565	566	568	569	570	572	573
7.10	0.000547	548	550	551	552	553	555	556	557	559	560
09	535	536	537	538	540	541	542	543	545	546	547
08	522	524	525	526	527	529	530	531	532	533	535
07	511	512	513	514	515	516	518	519	520	521	522
06	499	500	501	502	504	505	506	507	508	509	511
05	0.000488	489	490	491	492	493	494	495	497	498	499
04	476	478	479	480	481	482	483	484	485	486	488
03	466	467	468	469	470	471	472	473	474	475	476
02	455	456	457	458	459	460	461	462	463	465	466
01	445	446	447	448	449	450	451	452	453	454	455
7.00	0.000435	436	437	438	439	440	441	442	443	444	445

Proportional parts

	4	3
1	0.4	0.3
2	0.8	0.6
3	1.2	0.9
4	1.6	1.2
5	2.0	1.5
6	2.4	1.8
7	2.8	2.1
8	3.2	2.4
9	3.6	2.7

	2	1
1	0.2	0.1
2	0.4	0.2
3	0.6	0.3
4	0.8	0.4
5	1.0	0.5
6	1.2	0.6
7	1.4	0.7
8	1.6	0.8
9	1.8	0.9

Table B-14. Logarithms of (1/1-a) Continued

When *a* is positive:

Log *a*	0	1	2	3	4	5	6	7	8	9	10
7.0	0.000435	436	437	438	439	440	441	442	443	444	445
6.9	345	353	361	370	378	387	396	405	415	425	435
8	274	280	287	294	301	308	315	322	330	337	345
7	218	223	228	233	239	244	250	256	262	268	274
6	173	177	181	185	190	194	199	203	208	213	218
5	0.000137	141	144	147	151	154	158	161	165	169	173
4	109	112	114	117	120	122	125	128	131	134	137
3	087	089	091	093	095	097	100	102	104	107	109
2	69	70	72	74	75	77	79	81	83	85	87
1	55	56	57	59	60	61	63	64	66	67	69
6.0	0.000043	44	45	47	48	49	50	51	52	53	55
5.9	34	35	36	37	38	39	40	41	41	42	43
8	27	28	29	29	30	31	31	32	33	34	34
7	22	22	23	23	24	24	25	26	26	27	27
6	17	18	18	19	19	19	20	20	21	21	22
5	0.000014	14	14	15	15	15	16	16	17	17	17
4	11	11	11	12	12	12	13	13	13	13	14
3	09	09	09	09	10	10	10	10	10	11	11
2	7	7	7	7	8	8	8	8	8	8	9
1	5	6	6	6	6	6	6	6	7	7	7
5.0	0.000004	4	5	5	5	5	5	5	5	5	5
4.0	0.000000	1	1	1	1	1	2	2	3	3	4

When *a* is negative:

Log *a*	0	1	2	3	4	5	6	7	8	9	10
4.0 n	0.000000	*9999	*9999	*9999	*9999	*9999	*9998	*9998	*9997	*9997	*9996
5.0 n	9.999996	96	95	95	95	95	95	95	95	95	95
1 n	95	94	94	94	94	94	94	94	93	93	93
2 n	93	93	93	93	92	92	92	92	92	92	91
3 n	91	91	91	91	90	90	90	90	90	89	89
4 n	89	89	89	88	88	88	87	87	87	87	86
5 n	9.999986	86	86	85	85	85	84	84	83	83	83
6 n	83	82	82	81	81	81	80	80	79	79	78
7 n	78	78	77	77	76	76	75	74	74	73	73
8 n	73	72	71	71	70	69	69	68	67	66	66
9 n	66	65	64	63	62	61	60	59	59	58	57
6.0 n	9.999957	56	55	53	52	51	50	49	48	47	45
1 n	45	44	43	41	40	39	37	36	34	33	31
2 n	31	30	28	26	25	23	21	19	17	15	13
3 n	913	911	909	907	905	903	901	898	896	893	891
4 n	891	888	886	883	880	878	875	872	869	866	863
5 n	9.999863	859	856	853	849	846	842	839	835	831	827
6 n	827	823	819	815	810	806	802	797	792	787	782
7 n	782	777	772	767	761	756	750	744	738	732	726
8 n	726	720	713	706	700	693	685	678	671	663	655
9 n	655	647	639	631	622	613	604	595	585	576	566
7.0 n	9.999566	565	564	563	562	561	560	559	558	557	556

Proportional parts

	10	9
1	1.0	0.9
2	2.0	1.8
3	3.0	2.7
4	4.0	3.6
5	5.0	4.5
6	6.0	5.4
7	7.0	6.3
8	8.0	7.2
9	9.0	8.1

	8	7
1	0.8	0.7
2	1.6	1.4
3	2.4	2.1
4	3.2	2.8
5	4.0	3.5
6	4.8	4.2
7	5.6	4.9
8	6.4	5.6
9	7.2	6.3

	6	5
1	0.6	0.5
2	1.2	1.0
3	1.8	1.5
4	2.4	2.0
5	3.0	2.5
6	3.6	3.0
7	4.2	3.5
8	4.8	4.0
9	5.4	4.5

	4	3
1	0.4	0.3
2	0.8	0.6
3	1.2	0.9
4	1.6	1.2
5	2.0	1.5
6	2.4	1.8
7	2.8	2.1
8	3.2	2.4
9	3.6	2.7

	2	1
1	0.2	0.1
2	0.4	0.2
3	0.6	0.3
4	0.8	0.4
5	1.0	0.5
6	1.2	0.6
7	1.4	0.7
8	1.6	0.8
9	1.8	0.9

Table B-14. Logarithms of (1/1-a) Continued

When *a* is negative:

Log *a*	0	1	2	3	4	5	6	7	8	9	10
7.00 n	9.999566	565	564	563	562	561	560	559	558	557	556
01 n	556	555	554	553	552	551	550	549	548	547	545
02 n	545	544	543	542	541	540	539	538	537	536	535
03 n	535	534	533	532	531	530	528	527	526	525	524
04 n	524	523	522	521	520	519	517	516	515	514	513
05 n	9.999513	512	511	510	508	507	506	505	504	503	502
06 n	502	501	499	498	497	496	495	494	492	491	490
07 n	490	489	488	487	485	484	483	482	481	479	478
08 n	478	477	476	475	473	472	471	470	469	467	466
09 n	466	465	464	462	461	460	459	457	456	455	454
7.10 n	9.999454	452	451	450	449	447	446	445	443	442	441
11 n	441	440	438	437	436	434	433	432	430	429	428
12 n	428	427	425	424	423	421	420	419	417	416	415
13 n	415	413	412	410	409	408	406	405	404	402	401
14 n	401	400	398	397	395	394	393	391	390	388	387
15 n	9.999387	386	384	383	381	380	378	377	376	374	373
16 n	373	371	370	368	367	365	364	363	361	360	358
17 n	358	357	355	354	352	351	349	348	346	345	343
18 n	343	342	340	339	337	336	334	333	331	329	328
19 n	328	326	325	323	322	320	319	317	315	314	312
7.20 n	9.999312	311	309	307	306	304	303	301	299	298	296
21 n	296	295	293	291	290	288	286	285	283	282	280
22 n	280	278	277	275	273	272	270	268	266	265	263
23 n	263	261	260	258	256	255	253	251	249	247	246
24 n	246	244	242	241	239	237	235	234	232	230	228
25 n	9.999228	227	225	223	221	219	218	216	214	212	210
26 n	210	209	207	205	203	201	199	198	196	194	192
27 n	192	190	188	186	185	183	181	179	177	175	173
28 n	173	171	169	168	166	164	162	160	158	156	154
29 n	154	152	150	148	146	144	142	140	138	136	134
7.30 n	9.999134	132	130	128	126	124	122	120	118	116	114
31 n	114	112	110	108	106	104	102	100	098	096	094
32 n	094	091	089	087	085	083	081	079	077	075	072
33 n	072	070	068	066	064	062	060	057	055	053	051
34 n	051	049	047	044	042	040	038	036	033	031	029
35 n	9.999029	9027	9024	9022	9020	9018	9015	9013	9011	9009	9006
36 n	9006	9004	9002	8999	8997	8995	8992	8990	8988	8985	8983
37 n	8983	8981	8978	8976	8974	8971	8969	8967	8964	8962	8959
38 n	8959	8957	8955	8952	8950	8947	8945	8943	8940	8938	8935
39 n	8935	8933	8930	8928	8925	8923	8920	8918	8915	8913	8910
40 n	9.998910	8908	8905	8903	8900	8898	8895	8893	8890	8888	8885
41 n	8885	8883	8880	8877	8875	8872	8870	8867	8864	8862	8859
42 n	8859	8857	8854	8851	8849	8846	8843	8841	8838	8835	8833
43 n	8833	8830	8827	8825	8822	8819	8816	8814	8811	8808	8805
44 n	8805	8803	8800	8797	8794	8792	8789	8786	8783	8781	8778
45 n	9.998778	8775	8772	8769	8766	8764	8761	8758	8755	8752	8749
46 n	8749	8746	8744	8741	8738	8735	8732	8729	8726	8723	8720
47 n	8720	8717	8714	8711	8708	8705	8702	8699	8696	8693	8690
48 n	8690	8687	8684	8681	8678	8675	8672	8669	8666	8663	8660
49 n	8660	8657	8654	8651	8648	8644	8641	8638	8635	8632	8629
7.50 n	9.998629	8626	8622	8619	8616	8613	8610	8607	8603	8600	8597

Proportional parts

	1	2
1	0.1	0.2
2	0.2	0.4
3	0.3	0.6
4	0.4	0.8
5	0.5	1.0
6	0.6	1.2
7	0.7	1.4
8	0.8	1.6
9	0.9	1.8

	3	4
1	0.3	0.4
2	0.6	0.8
3	0.9	1.2
4	1.2	1.6
5	1.5	2.0
6	1.8	2.4
7	2.1	2.8
8	2.4	3.2
9	2.7	3.6

Table B-14. Logarithms of (1/1-a) Continued

When *a* is negative:

Log *a*	0	1	2	3	4	5	6	7	8	9	10
7.50 n	9.998629	8626	8622	8619	8616	8613	8610	8607	8603	8600	8597
51 n	8597	8594	8590	8587	8584	8581	8577	8574	8571	8568	8564
52 n	8564	8561	8558	8554	8551	8548	8544	8541	8538	8534	8531
53 n	8531	8528	8524	8521	8517	8514	8511	8507	8504	8500	8497
54 n	8497	8493	8490	8486	8483	8479	8476	8472	8469	8465	8462
55 n	9.998462	8458	8455	8451	8448	8444	8440	8437	8433	8430	8426
56 n	8426	8422	8419	8415	8411	8408	8404	8400	8397	8393	8389
57 n	8389	8386	8382	8378	8375	8371	8367	8363	8360	8356	8352
58 n	8352	8348	8344	8341	8337	8333	8329	8325	8321	8318	8314
59 n	8314	8310	8306	8302	8298	8294	8290	8286	8282	8278	8274
7.60 n	9.998274	8271	8267	8263	8259	8255	8251	8246	8242	8238	8234
61 n	8234	8230	8226	8222	8218	8214	8210	8206	8202	8197	8193
62 n	8193	8189	8185	8181	8177	8172	8168	8164	8160	8156	8151
63 n	8151	8147	8143	8139	8134	8130	8126	8121	8117	8113	8108
64 n	8108	8104	8100	8095	8091	8087	8082	8078	8073	8069	8064
65 n	9.998064	8060	8055	8051	8047	8042	8380	8033	8028	8024	8019
66 n	8019	8015	8010	8006	8001	7997	7992	7987	7983	7978	7973
67 n	7973	7969	7964	7959	7955	7950	7945	7941	7936	7931	7926
68 n	7926	7922	7917	7912	7907	7902	7898	7893	7888	7883	7878
69 n	7878	7873	7868	7863	7859	7854	7849	7844	7839	7834	7829
7.70 n	9.997829	7824	7819	7814	7809	7804	7799	7794	7789	7783	7778
71 n	7778	7773	7768	7763	7758	7753	7748	7742	7737	7732	7727
72 n	7727	7722	7716	7711	7706	7700	7695	7690	7685	7679	7674
73 n	7674	7669	7663	7658	7652	7647	7642	7636	7631	7625	7620
74 n	7620	7614	7609	7603	7598	7592	7587	7581	7576	7570	7565
75 n	9.997565	7559	7553	7548	7542	7537	7531	7525	7519	7514	7508
76 n	7508	7502	7497	7491	7485	7479	7473	7468	7462	7456	7450
77 n	7450	7444	7438	7433	7427	7421	7415	7409	7403	7397	7391
78 n	7391	7385	7379	7373	7367	7361	7355	7349	7343	7337	7330
79 n	7330	7324	7318	7312	7306	7300	7293	7287	7281	7275	7268
7.80 n	9.997268	7262	7256	7250	7243	7237	7231	7224	7218	7211	7205
81 n	7205	7199	7192	7186	7179	7173	7166	7160	7153	7147	7140
82 n	7140	7134	7127	7120	7114	7107	7100	7094	7087	7080	7074
83 n	7074	7067	7060	7053	7047	7040	7033	7026	7019	7013	7006
84 n	7006	6999	6992	6985	6978	6971	6964	6957	6950	6943	6936
85 n	9.996936	6929	6922	6915	6908	6901	6894	6887	6880	6872	6865
86 n	6865	6858	6851	6844	6836	6829	6822	6814	6807	6800	6792
87 n	6792	6785	6778	6770	6763	6755	6748	6740	6733	6725	6718
88 n	6718	6710	6703	6695	6688	6680	6672	6665	6657	6650	6642
89 n	6642	6634	6626	6619	6611	6603	6595	6587	6580	6572	6564
90 n	9.996564	6556	6548	6540	6532	6524	6516	6508	6500	6492	6484
91 n	6484	6476	6468	6460	6452	6444	6435	6427	6419	6411	6403
92 n	6403	6394	6386	6378	6369	6361	6353	6344	6336	6328	6319
93 n	6319	6311	6302	6294	6285	6277	6268	6260	6251	6242	6234
94 n	6324	6225	6217	6208	6199	6190	6182	6173	6164	6155	6146
95 n	9.996146	6138	6129	6120	6111	6102	6093	6084	6075	6066	6057
96 n	6057	6048	6039	6030	6021	6012	6003	5993	5984	5975	5966
97 n	5966	5956	5947	5938	5929	5919	5910	5900	5891	5882	5872
98 n	5872	5863	5853	5844	5834	5825	5815	5805	5796	5786	5777
99 n	5777	5767	5757	5747	5738	5728	5718	5708	5698	5689	5679
8.00 n	9.995679	5669	5659	5649	5639	5629	5619	5609	5599	5589	5578

Proportional parts

	4	5
1	0.4	0.5
2	0.8	1.0
3	1.2	1.5
4	1.6	2.0
5	2.0	2.5
6	2.4	3.0
7	2.8	3.5
8	3.2	4.0
9	3.6	4.5

	6	7
1	0.6	0.7
2	1.2	1.4
3	1.8	2.1
4	2.4	2.8
5	3.0	3.5
6	3.6	4.2
7	4.2	4.9
8	4.8	5.6
9	5.4	6.3

	8	9
1	0.8	0.9
2	1.6	1.8
3	2.4	2.7
4	3.2	3.6
5	4.0	4.5
6	4.8	5.4
7	5.6	6.3
8	6.4	7.2
9	7.2	8.1

	10	11
1	1.0	1.1
2	2.0	2.2
3	3.0	3.3
4	4.0	4.4
5	5.0	5.5
6	6.0	6.6
7	7.0	7.7
8	8.0	8.8
9	9.0	9.9

Table B-14. Logarithms of (1/1-a) Continued

When *a* is negative:

Log *a*	0	1	2	3	4	5	6	7	8	9	10
8.00 n	9.995679	5669	5659	5649	5639	5629	5619	5609	5599	5589	5578
01 n	5578	5568	5558	5548	5538	5528	5517	5507	5497	5486	5476
02 n	5476	5466	5455	5445	5434	5424	5413	5403	5392	5382	5371
03 n	5371	5361	5350	5339	5329	5318	5307	5296	5286	5275	5264
04 n	5264	5253	5242	5231	5220	5209	5198	5187	5176	5165	5154
05 n	9.995154	5143	5132	5121	5110	5098	5087	5076	5065	5053	5042
06 n	5042	5031	5019	5008	4996	4985	4973	4962	4950	4939	4927
07 n	4927	4916	4904	4892	4881	4869	4857	4845	4833	4822	4810
08 n	4810	4798	4786	4774	4762	4750	4738	4726	4714	4702	4690
09 n	4690	4677	4665	4653	4641	4628	4616	4604	4591	4579	4567
8.10 n	9.994567	4554	4542	4529	4517	4504	4492	4479	4466	4454	4441
11 n	4441	4428	4415	4403	4390	4377	4364	4351	4338	4325	4312
12 n	4312	4299	4286	4273	4260	4247	4234	4220	4207	4194	4181
13 n	4181	4167	4154	4141	4127	4114	4100	4087	4073	4060	4046
14 n	4046	4032	4019	4005	3991	3978	3964	3950	3936	3922	3908
15 n	9.993908	3894	3880	3866	3852	3838	3824	3810	3796	3782	3767
16 n	3767	3753	3739	3725	3710	3696	3681	3667	3652	3638	3623
17 n	3623	3609	3594	3579	3565	3550	3535	3521	3506	3491	3476
18 n	3476	3461	3446	3431	3416	3401	3386	3371	3356	3340	3325
19 n	3325	3310	3295	3279	3264	3248	3233	3218	3202	3186	3171
8.20 n	9.993371	3155	3140	3124	3108	3092	3077	3061	3045	3029	3013
21 n	3013	2997	2981	2965	2949	2933	2917	2900	2884	2868	2852
22 n	2852	2835	2819	2803	2786	2770	2753	2736	2720	2703	2687
23 n	2687	2670	2653	2636	2619	2603	2586	2569	2552	2535	2518
24 n	2518	2501	2483	2466	2449	2432	2414	2397	2380	2362	2345
25 n	9.992345	2327	2310	2292	2275	2257	2239	2222	2204	2186	2168
26 n	2168	2150	2132	2114	2096	2078	2060	2042	2024	2006	1987
27 n	1987	1969	1951	1932	1914	1896	1877	1858	1840	1821	1803
28 n	1803	1784	1765	1746	1727	1709	1690	1671	1652	1633	1613
29 n	1613	1594	1575	1556	1537	1517	1498	1478	1459	1440	1420
8.30 n	9.991420	1400	1381	1361	1341	1322	1302	1282	1262	1242	1222
31 n	1222	1202	1182	1162	1142	1122	1101	1081	1061	1040	1020
32 n	1020	0999	0979	0958	0938	0917	0896	0875	0855	0834	0813
33 n	0813	0792	0771	0750	0729	0708	0686	0665	0644	0622	0601
34 n	0601	0580	0558	0537	0515	0493	0472	0450	0428	0406	0385
35 n	9.990385	0363	0341	0319	0297	0274	0252	0230	0208	0186	0163
36 n	9.990163	0141	0118	0096	0073	0051	0028	0005	*9982	*9960	*9937
37 n	9.989937	9914	9891	9868	9845	9821	9798	9775	9752	9728	9705
38 n	9705	9682	9658	9634	9611	9587	9563	9540	9516	9492	9468
39 n	9468	9444	9420	9396	9372	9348	9323	9299	9275	9250	9226
40 n	9.989226	9201	9177	9152	9127	9103	9078	9053	9028	9003	8978
41 n	8978	8953	8928	8903	8877	8852	8827	8801	8776	8750	8725
42 n	8725	8699	8673	8647	8622	8596	8570	8544	8518	8492	8465
43 n	8465	8439	8413	8386	8360	8334	8307	8280	8254	8227	8200
44 n	8200	8173	8147	8120	8093	8066	8038	8011	7984	7957	7929
45 n	9.987929	7902	7874	7847	7819	7791	7764	7736	7708	7680	7652
46 n	7652	7624	7596	7568	7539	7511	7483	7454	7426	7397	7369
47 n	7369	7340	7311	7282	7253	7224	7195	7166	7137	7108	7079
48 n	7079	7049	7020	6990	6961	6931	6902	6872	6842	6812	6782
49 n	6782	6752	6722	6692	6662	6631	6601	6571	6540	6510	6479
8.50 n	9.986479	6448	6418	6387	6356	6325	6294	6263	6232	6200	6169

Proportional parts

	10	11	12	13	14
1	1.0	1.1	1.2	1.3	1.4
2	2.0	2.2	2.4	2.6	2.8
3	3.0	3.3	3.6	3.9	4.2
4	4.0	4.4	4.8	5.2	5.6
5	5.0	5.5	6.0	6.5	7.0
6	6.0	6.6	7.2	7.8	8.4
7	7.0	7.7	8.4	9.1	9.8
8	8.0	8.8	9.6	10.4	11.2
9	9.0	9.9	10.8	11.7	12.6

	15	16	17	18	19
1	1.5	1.6	1.7	1.8	1.9
2	3.0	3.2	3.4	3.6	3.8
3	4.5	4.8	5.1	5.4	5.7
4	6.0	6.4	6.8	7.2	7.6
5	7.5	8.0	8.5	9.0	9.5
6	9.0	9.6	10.2	10.8	11.4
7	10.5	11.2	11.9	12.6	13.3
8	12.0	12.8	13.6	14.4	15.2
9	13.5	14.4	15.3	16.2	17.1

	20	21	22	23	24
1	2.0	2.1	2.2	2.3	2.4
2	4.0	4.2	4.4	4.6	4.8
3	6.0	6.3	6.6	6.9	7.2
4	8.0	8.4	8.8	9.2	9.6
5	10.0	10.5	11.0	11.5	12.0
6	12.0	12.6	13.2	13.8	14.4
7	14.0	14.7	15.4	16.1	16.8
8	16.0	16.8	17.6	18.4	19.2
9	18.0	18.9	19.8	20.7	21.6

	25	26	27	28	29
1	2.5	2.6	2.7	2.8	2.9
2	5.0	5.2	5.4	5.6	5.8
3	7.5	7.8	8.1	8.4	8.7
4	10.0	10.4	10.8	11.2	11.6
5	12.5	13.0	13.5	14.0	14.5
6	15.0	15.6	16.2	16.8	17.4
7	17.5	18.2	18.9	19.6	20.3
8	20.0	20.8	21.6	22.4	23.2
9	22.5	23.4	24.3	25.2	26.1

	30	31	32
1	3.0	3.1	3.2
2	6.0	6.2	6.4
3	9.0	9.3	9.6
4	12.0	12.4	12.8
5	15.0	15.5	16.0
6	18.0	18.6	19.2
7	21.0	21.7	22.4
8	24.0	24.8	25.6
9	27.0	27.9	28.8

Table B-14. Logarithms of (1/1-a) Continued

When *a* is negative:

Log *a*	0	1	2	3	4	5	6	7	8	9	10
8.50 n	9.986479	6448	6418	6387	6356	6325	6294	6263	6232	6200	6169
51 n	6169	6138	6106	6075	6043	6011	5980	5948	5916	5884	5852
52 n	5852	5820	5788	5756	5723	5691	5659	5626	5593	5561	5528
53 n	5528	5495	5462	5429	5396	5363	5330	5297	5263	5230	5197
54 n	5197	5163	5129	5096	5062	5028	4994	4960	4926	4892	4858
55 n	9.984858	4823	4789	4755	4720	4685	4651	4616	4581	4546	4511
56 n	4511	4476	4441	4406	4370	4335	4300	4264	4228	4193	4157
57 n	4157	4121	4085	4049	4013	3977	3941	3904	3868	3831	3795
58 n	3795	3758	3721	3684	3648	3611	3573	3536	3499	3462	3424
59 n	3424	3387	3349	3312	3274	3236	3198	3160	3122	3084	3046
8.60 n	9.983046	3007	2969	2930	2892	2853	2814	2776	2737	2698	2658
61 n	2658	2619	2580	2541	2501	2462	2422	2382	2343	2303	2263
62 n	2263	2223	2183	2142	2102	2062	2021	1981	1940	1899	1858
63 n	1858	1817	1776	1735	1694	1653	1611	1570	1528	1486	1444
64 n	1444	1403	1361	1319	1276	1234	1192	1149	1107	1064	1022
65 n	9.981022	0979	0936	0893	0850	0807	0763	0720	0677	0633	0589
66 n	0589	0546	0502	0458	0414	0370	0325	0281	0237	0192	0147
67 n	9.980147	0103	0058	0013	*9968	*9923	*9878	*9832	*9787	*9741	*9695
68 n	9.979695	9650	9604	9558	9512	9466	9420	9373	9327	9280	9234
69 n	9234	9187	9040	9093	9046	8999	8952	8904	8857	8809	8762
8.70 n	9.978762	8714	8666	8618	8570	8522	8473	8425	8376	8328	8279
71 n	8279	8230	8181	8132	8083	8034	7985	7935	7885	7836	7786
72 n	7786	7736	7686	7636	7586	7535	7485	7434	7384	7333	7282
73 n	7282	7231	7180	7128	7077	7026	6974	6922	6870	6818	6766
74 n	6766	6714	6662	6610	6557	6505	6452	6399	6346	6293	6240
75 n	9.976240	6187	6133	6080	6026	5972	5918	5864	5810	5756	5702
76 n	5702	5647	5593	5538	5483	5428	5373	5318	5262	5207	5152
77 n	5152	5096	5040	4983	4928	4872	4816	4759	4703	4646	4589
78 n	4589	4532	4475	4418	4361	4304	4246	4188	4131	4073	4015
79 n	4015	3957	3898	3840	3781	3723	3664	3605	3546	3487	3428
8.80 n	9.973428	3368	3309	3249	3189	3129	3069	3009	2949	2888	2828
81 n	2828	2767	2706	2645	2584	2523	2461	2400	2338	2276	2215
82 n	2215	2153	2090	2028	1966	1903	1840	1777	1714	1651	1588
83 n	1588	1525	1461	1398	1334	1270	1206	1141	1077	1013	0948
84 n	0948	0883	0818	0753	0688	0623	0557	0492	0426	0360	0294
85 n	9.970294	0228	0161	0095	0028	*9962	*9895	*9828	*9760	*9693	*9626
86 n	9.969626	9558	9490	9422	9354	9286	9218	9149	9081	9012	8943
87 n	8943	8874	8804	8735	8666	8596	8526	8456	8386	8316	8245
88 n	8245	8175	8104	8033	7962	7891	7819	7748	7676	7604	7532
89 n	7532	7460	7388	7316	7243	7170	7097	7024	6951	6878	6804
90 n	9.966804	6731	6657	6583	6509	6435	6360	6285	6211	6136	6061
91 n	6061	5985	5910	5834	5759	5683	5607	5531	5454	5378	5301
92 n	5301	5224	5147	5070	4992	4915	4837	4759	4681	4603	4525
93 n	4525	4446	4368	4289	4210	4130	4051	3972	3892	3812	3732
94 n	3732	3652	3571	3491	3410	3329	3248	3167	3086	3004	2922
95 n	9.962922	2840	2758	2676	2594	2511	2428	2345	2262	2179	2095
96 n	2095	2012	1928	1844	1760	1675	1591	1506	1421	1336	1251
97 n	1251	1165	1080	0994	0908	0822	0735	0649	0562	0475	0388
98 n	9.960388	0301	0213	0126	0038	*9950	*9862	*9773	*9685	*9596	*9507
99 n	9.959507	9418	9329	9239	9149	9059	8969	8879	8789	8698	8607
9.00 n	9.958607	8516	8425	8334	8242	8150	8058	7966	7874	7781	7689

Proportional parts					
	32	34	36	38	40
1	3.2	3.4	3.6	3.8	4.0
2	6.4	6.8	7.2	7.6	8.0
3	9.6	10.2	10.8	11.4	12.0
4	12.8	13.6	14.4	15.2	16.0
5	16.0	17.0	18.0	19.0	20.0
6	19.2	20.4	21.6	22.8	24.0
7	22.4	23.8	25.2	26.6	28.0
8	25.6	27.2	28.8	30.4	32.0
9	28.8	30.6	32.4	34.2	36.0
	42	44	46	48	50
1	4.2	4.4	4.6	4.8	5.0
2	8.4	8.8	9.2	9.6	10.0
3	12.6	13.2	13.8	14.4	15.0
4	16.8	17.6	18.4	19.2	20.0
5	21.0	22.0	23.0	24.0	25.0
6	25.2	26.4	27.6	28.8	30.0
7	29.4	30.8	32.2	33.6	35.0
8	33.6	35.2	36.8	38.4	40.0
9	37.8	39.6	41.4	43.2	45.0
	52	54	56	58	60
1	5.2	5.4	5.6	5.8	6.0
2	10.4	10.8	11.2	11.6	12.0
3	15.6	16.2	16.8	17.4	18.0
4	20.8	21.6	22.4	23.2	24.0
5	26.0	27.0	28.0	29.0	30.0
6	31.2	32.4	33.6	34;8	36.0
7	36.4	37.8	39.2	40.6	42.0
8	41.6	43.2	44.8	46.4	48.0
9	46.8	48.6	50.4	52.2	54.0
	62	64	66	68	70
1	6.2	6.4	6.6	6.8	7.0
2	12.4	12.8	13.2	13.6	14.0
3	18.6	19.2	19.8	20.4	21.0
4	24.8	25.6	26.4	27.2	28.0
5	31.0	32.0	33.0	34.0	35.0
6	37.2	38.4	39.6	40.8	42.0
7	43.4	44.8	46.2	47.6	49.0
8	49.6	51.2	52.8	54.4	56.0
9	55.8	57.6	59.4	61.2	63.0
	72	74	76	78	80
1	7.2	7.4	7.6	7.8	8.0
2	14.4	14.8	15.2	15.6	16.0
3	21.6	22.2	22.8	23.4	24.0
4	28.8	29.6	30.4	31.2	32.0
5	36.0	37.0	38.0	39.0	40.0
6	43.2	44.4	45.6	46.8	48.0
7	50.4	51.8	53.2	54.6	56.0
8	57.6	59.2	60.8	62.4	64.0
9	64.7	66.6	68.4	70.2	72.0
	82	84	86	88	90
1	8.2	8.4	8.6	8.8	9.0
2	16.4	16.8	17.2	17.6	18.0
3	24.6	25.2	25.8	26.4	27.0
4	32.8	33.6	34.4	35.2	36.0
5	41.0	42.0	43.0	44.0	45.0
6	49.2	50.4	51.6	52.8	54.0
7	57.4	58.8	60.2	61.6	63.0
8	65.6	67.2	68.8	70.4	72.0
9	73.8	75.6	77.4	79.2	81.0

Table B-15. Curvature Correction For Polaris

Azimuth Of Polaris \ T	1 m	2 m	3 m	4 m	5 m	6 m	7 m	8 m	9 m	10 m
° ′	″	″	″	″	″	″	″	″	″	″
0 00	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
10	.0	.0	.0	.0	.0	.1	.1	.1	.1	.1
20	.0	.0	.0	.0	.1	.1	.1	.2	.2	.3
30	.0	.0	.0	.1	.1	.2	.2	.3	.3	.4
40	.0	.0	.1	.1	.1	.2	.3	.4	.5	.6
50	.0	.0	.1	.1	.2	.3	.3	.5	.6	.7
1 00	.0	.0	.1	.1	.2	.3	.4	.5	.7	.9
10	.0	.0	.1	.2	.2	.4	.5	.6	.8	1.0
20	.0	.0	.1	.2	.3	.4	.6	.7	.9	1.1
30	.0	.0	.1	.2	.3	.5	.6	.8	1.0	1.3
40	.0	.1	.1	.2	.4	.5	.7	.9	1.2	1.4
50	.0	.1	.1	.3	.4	.6	.8	1.0	1.3	1.6
2 00	.0	.1	.2	.3	.4	.6	.8	1.1	1.4	1.7
10	.0	.1	.2	.3	.5	.7	.9	1.2	1.5	1.9
20	.0	.1	.2	.3	.5	.7	1.0	1.3	1.6	2.0
30	.0	.1	.2	.3	.5	.8	1.1	1.4	1.7	2.1
40	.0	.1	.2	.4	.6	.8	1.1	1.5	1.9	2.3
50	.0	.1	.2	.4	.6	.9	1.2	1.6	2.0	2.4
3 00	.0	.1	.2	.4	.6	.9	1.3	1.6	2.1	2.6
10	.0	.1	.2	.4	.7	1.0	1.3	1.7	2.2	2.7

Table B-16. Conversion of Barometric Pressure

(From meters to inches or millimeters of mercury)

For in Hg, $P = 29.9212 \left(\frac{87.783 - 0.00198h}{87.783} \right)^{5.256}$

For mm Hg, $P = 760 \left(\frac{87.783 - 0.00198h}{87.783} \right)^{5.256}$

Where: h is the reduced altitude in meters.

(When the altimeter reading is in feet, convert reduced altitude in feet to meters) (meters = feet x 0.3048)

Altitude (meters)	Barometric Pressure		Altitude (meters)	Barometric Pressure		Altitude (meters)	Barometric Pressure	
h	in Hg	mm Hg	h	in Hg	mm Hg	h	in Hg	mm Hg
-400	31.367	796.72	1250	25.745	653.92	2900	20.968	532.59
-350	31.184	792.07	1300	25.589	649.96	2950	20.835	529.21
-300	31.001	787.43	1350	25.433	645.99	3000	20.703	525.86
-250	30.819	782.80	1400	25.278	642.06	3050	20.572	522.53
-200	30.637	778.18	1450	25.123	638.12	3100	20.442	519.23
-150	30.457	773.61	1500	24.970	634.24	3150	20.312	515.92
-100	30.278	769.06	1550	24.817	630.35	3200	20.182	512.62
- 50	30.099	764.51	1600	24.665	626.49	3250	20.054	509.37
0	29.921	760.00	1650	24.513	622.63	3300	19.926	506.12
+ 50	29.744	755.50	1700	24.363	618.82	3350	19.799	502.89
100	29.568	751.03	1750	24.213	615.01	3400	19.672	499.67
150	29.393	746.58	1800	24.064	611.22	3450	19.546	496.47
200	29.219	742.16	1850	23.916	607.47	3500	19.421	493.29
250	29.045	737.74	1900	23.768	603.71	3550	19.296	490.12
300	28.872	733.35	1950	23.621	599.97	3600	19.172	486.97
350	28.700	728.98	2000	23.475	596.27	3650	19.049	483.84
400	28.529	724.64	2050	23.330	592.58	3700	18.926	480.72
450	28.359	720.32	2100	23.185	588.90	3750	18.804	477.62
500	28.190	716.03	2150	23.041	585.24	3800	18.682	474.52
550	28.021	711.73	2200	22.898	581.61	3850	18.561	471.45
600	27.853	707.47	2250	22.756	578.00	3900	18.441	468.40
650	27.686	703.22	2300	22.614	574.40	3950	18.322	465.38
700	27.520	699.01	2350	22.473	570.81	4000	18.203	462.36
750	27.355	694.82	2400	22.333	567.26	4050	18.085	459.36
800	27.190	690.63	2450	22.193	563.70	4100	17.967	456.36
850	27.026	686.46	2500	22.054	560.17	4150	17.850	453.39
900	26.864	682.35	2550	21.916	556.67	4200	17.734	450.44
950	26.701	678.21	2600	21.778	553.16	4250	17.618	447.50
1000	26.540	674.12	2650	21.642	549.71	4300	17.503	444.58
1050	26.380	670.05	2700	21.506	546.25	4350	17.388	441.66
1100	26.220	665.99	2750	21.370	542.80	4400	17.274	438.76
1150	26.061	661.95	2800	21.235	539.37	4450	17.161	435.89
1200	25.903	657.94	2850	21.101	535.97	4500	17.048	433.02
1250	25.745	653.92	2900	20.968	532.59			

The inches of Hg values in this table were computed from the formula and the mm of Hg values were computed from the inch values.

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APPENDIX C

TRIGONOMETRIC FUNCTIONS (TIME)

This appendix is an exact duplication of the *Tables of the Natural Values of the Four Trigonometrical Functions SINE, TANGENT, COTANGENT, COSINE for Every Second of Time in the Quadrant generally to SEVEN DECIMALS,* 2d Edition, 1958.

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$0^{h}\ 00^{m}$ | $0^{h}\ 01^{m}$

d	728–727	727–728	∞–389	0–3	728–727	727–728	3757–963	3–7	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·000 0000	0·000 0000	∞	1·000 0000	0·004 3633	0·004 3634	229·182	0·999 9905	60
01	·000 0727	·000 0727	13751·0	1·000 0000	·004 4360	·004 4361	225·425	·999 9902	59
02	·000 1454	·000 1454	6875·5	1·000 0000	·004 5088	·004 5088	221·789	·999 9898	58
03	·000 2182	·000 2182	4583·7	1·000 0000	·004 5815	·004 5815	218·268	·999 9895	57
04	·000 2909	·000 2909	3437·7	1·000 0000	·004 6542	·004 6542	214·858	·999 9892	56
05	0·000 3636	0·000 3636	2750·2	0·999 9999	0·004 7269	0·004 7270	211·552	0·999 9888	55
06	·000 4363	·000 4363	2291·8	·999 9999	·004 7996	·004 7997	208·347	·999 9885	54
07	·000 5091	·000 5091	1964·4	·999 9999	·004 8724	·004 8724	205·237	·999 9881	53
08	·000 5818	·000 5818	1718·9	·999 9998	·004 9451	·004 9451	202·219	·999 9878	52
09	·000 6545	·000 6545	1527·9	·999 9998	·005 0178	·005 0179	199·288	·999 9874	51
10	0·000 7272	0·000 7272	1375·1	0·999 9997	0·005 0905	0·005 0906	196·441	0·999 9870	50
11	·000 7999	·000 7999	1250·1	·999 9997	·005 1632	·005 1633	193·674	·999 9867	49
12	·000 8727	·000 8727	1145·9	·999 9996	·005 2360	·005 2360	190·984	·999 9863	48
13	·000 9454	·000 9454	1057·8	·999 9996	·005 3087	·005 3088	188·368	·999 9859	47
14	·001 0181	·001 0181	982·21	·999 9995	·005 3814	·005 3815	185·822	·999 9855	46
15	0·001 0908	0·001 0908	916·73	0·999 9994	0·005 4541	0·005 4542	183·345	0·999 9851	45
16	·001 1636	·001 1636	859·44	·999 9993	·005 5268	·005 5269	180·932	·999 9847	44
17	·001 2363	·001 2363	808·88	·999 9992	·005 5996	·005 5997	178·582	·999 9843	43
18	·001 3090	·001 3090	763·94	·999 9991	·005 6723	·005 6724	176·293	·999 9839	42
19	·001 3817	·001 3817	723·74	·999 9990	·005 7450	·005 7451	174·061	·999 9835	41
20	0·001 4544	0·001 4544	687·55	0·999 9989	0·005 8177	0·005 8178	171·885	0·999 9831	40
21	·001 5272	·001 5272	654·81	·999 9988	·005 8905	·005 8906	169·763	·999 9827	39
22	·001 5999	·001 5999	625·04	·999 9987	·005 9632	·005 9633	167·693	·999 9822	38
23	·001 6726	·001 6726	597·87	·999 9986	·006 0359	·006 0360	165·673	·999 9818	37
24	·001 7453	·001 7453	572·96	·999 9985	·006 1086	·006 1087	163·700	·999 9813	36
25	0·001 8181	0·001 8181	550·04	0·999 9983	0·006 1813	0·006 1815	161·774	0·999 9809	35
26	·001 8908	·001 8908	528·88	·999 9982	·006 2541	·006 2542	159·893	·999 9804	34
27	·001 9635	·001 9635	509·30	·999 9981	·006 3268	·006 3269	158·055	·999 9800	33
28	·002 0362	·002 0362	491·11	·999 9979	·006 3995	·006 3996	156·259	·999 9795	32
29	·002 1089	·002 1089	474·17	·999 9978	·006 4722	·006 4724	154·503	·999 9791	31
30	0·002 1817	0·002 1817	458·37	0·999 9976	0·006 5449	0·006 5451	152·787	0·999 9786	30
31	·002 2544	·002 2544	443·58	·999 9975	·006 6177	·006 6178	151·108	·999 9781	29
32	·002 3271	·002 3271	429·72	·999 9973	·006 6904	·006 6905	149·465	·999 9776	28
33	·002 3998	·002 3998	416·70	·999 9971	·006 7631	·006 7633	147·858	·999 9771	27
34	·002 4725	·002 4726	404·44	·999 9969	·006 8358	·006 8360	146·285	·999 9766	26
35	0·002 5453	0·002 5453	392·88	0·999 9968	0·006 9085	0·006 9087	144·745	0·999 976-	25
36	·002 6180	·002 6180	381·97	·999 9966	·006 9813	·006 9814	143·237	·999 9756	24
37	·002 6907	·002 6907	371·65	·999 9964	·007 0540	·007 0542	141·760	·999 9751	23
38	·002 7634	·002 7634	361·87	·999 9962	·007 1267	·007 1269	140·314	·999 9746	22
39	·002 8362	·002 8362	352·59	·999 9960	·007 1994	·007 1996	138·896	·999 9741	21
40	0·002 9089	0·002 9089	343·77	0·999 9958	0·007 2721	0·007 2723	137·507	0·999 9736	20
41	·002 9816	·002 9816	335·39	·999 9956	·007 3449	·007 3451	136·146	·999 9730	19
42	·003 0543	·003 0543	327·40	·999 9953	·007 4176	·007 4178	134·811	·999 9725	18
43	·003 1270	·003 1271	319·79	·999 9951	·007 4903	·007 4905	133·502	·999 9719	17
44	·003 1998	·003 1998	312·52	·999 9949	·007 5630	·007 5632	132·219	·999 9714	16
45	0·003 2725	0·003 2725	305·58	0·999 9946	0·007 6357	0·007 6360	130·959	0·999 9708	15
46	·003 3452	·003 3452	298·93	·999 9944	·007 7085	·007 7087	129·724	·999 9703	14
47	·003 4179	·003 4179	292·57	·999 9942	·007 7812	·007 7814	128·511	·999 9697	13
48	·003 4907	·003 4907	286·48	·999 9939	·007 8539	·007 8541	127·321	·999 9692	12
49	·003 5634	·003 5634	280·63	·999 9937	·007 9266	·007 9269	126·153	·999 9686	11
50	0·003 6361	0·003 6361	275·02	0·999 9934	0·007 9993	0·007 9996	125·006	0·999 9680	10
51	·003 7088	·003 7088	269·63	·999 9931	·008 0721	·008 0723	123·880	·999 9674	09
52	·003 7815	·003 7816	264·44	·999 9928	·008 1448	·008 1450	122·774	·999 9668	08
53	·003 8543	·003 8543	259·45	·999 9926	·008 2175	·008 2178	121·687	·999 9662	07
54	·003 9270	·003 9270	254·65	·999 9923	·008 2902	·008 2905	120·620	·999 9656	06
55	0·003 9997	0·003 9997	250·02	0·999 9920	0·008 3629	0·008 3632	119·571	0·999 9650	05
56	·004 0724	·004 0725	245·55	·999 9917	·008 4357	·008 4360	118·540	·999 9644	04
57	·004 1451	·004 1452	241·24	·999 9914	·008 5084	·008 5087	117·527	·999 9638	03
58	·004 2179	·004 2179	237·08	·999 9911	·008 5811	·008 5814	116·531	·999 9632	02
59	·004 2906	·004 2906	233·07	·999 9908	·008 6538	·008 6541	115·552	·999 9626	01
60	0·004 3633	0·004 3634	229·18	0·999 9905	0·008 7265	0·008 7269	114·589	0·999 9619	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	727–728	728–727	389–∞	3–0	727–728	728–727	963–3757	7–3	d

$5^{h}\ 59^{m}$ | $5^{h}\ 58^{m}$

$0^{h}\ 02^{m}$ — $0^{h}\ 03^{m}$

d	728–727	727–728	947–427	6–10	728–727	727–728	422–240	9–13	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·008 7265	0·008 7269	114·589	0·999 9619	0·013 0896	0·013 0907	76·390	0·999 9143	60
01	·008 7993	·008 7996	113·642	·999 9613	·013 1623	·013 1635	75·968	·999 9134	59
02	·008 8720	·008 8723	112·710	·999 9606	·013 2350	·013 2362	75·550	·999 9124	58
03	·008 9447	·008 9451	111·794	·999 9600	·013 3077	·013 3089	75·138	·999 9114	57
04	·009 0174	·009 0178	110·892	·999 9593	·013 3805	·013 3817	74·729	·999 9105	56
05	0·009 0901	0·009 0905	110·005	0·999 9587	0·013 4532	0·013 4544	74·325	0·999 9095	55
06	·009 1629	·009 1632	109·132	·999 9580	·013 5259	·013 5271	73·926	·999 9085	54
07	·009 2356	·009 2360	108·272	·999 9574	·013 5986	·013 5999	73·530	·999 9075	53
08	·009 3083	·009 3087	107·426	·999 9567	·013 6713	·013 6726	73·139	·999 9065	52
09	·009 3810	·009 3814	106·594	·999 9560	·013 7440	·013 7453	72·752	·999 9055	51
10	0·009 4537	0·009 4541	105·774	0·999 9553	0·013 8168	0·013 8181	72·369	0·999 9045	50
11	·009 5264	·009 5269	104·966	·999 9546	·013 8895	·013 8908	71·990	·999 9035	49
12	·009 5992	·009 5996	104·171	·999 9539	·013 9622	·013 9635	71·615	·999 9025	48
13	·009 6719	·009 6723	103·388	·999 9532	·014 0349	·014 0363	71·244	·999 9015	47
14	·009 7446	·009 7451	102·616	·999 9525	·014 1076	·014 1090	70·877	·999 9005	46
15	0·009 8173	0·009 8178	101·856	0·999 9518	0·014 1803	0·014 1818	70·513	0·999 8995	45
16	·009 8900	·009 8905	101·107	·999 9511	·014 2530	·014 2545	70·153	·999 8984	44
17	·009 9628	·009 9633	100·369	·999 9504	·014 3258	·014 3272	69·797	·999 8974	43
18	·010 0355	·010 0360	99·641	·999 9496	·014 3985	·014 4000	69·445	·999 8963	42
19	·010 1082	·010 1087	98·925	·999 9489	·014 4712	·014 4727	69·096	·999 8953	41
20	0·010 1809	0·010 1814	98·218	0·999 9482	0·014 5439	0·014 5454	68·750	0·999 8942	40
21	·010 2536	·010 2542	97·521	·999 9474	·014 6166	·014 6182	68·408	·999 8932	39
22	·010 3263	·010 3269	96·834	·999 9467	·014 6893	·014 6909	68·069	·999 8921	38
23	·010 3991	·010 3996	96·157	·999 9459	·014 7620	·014 7636	67·734	·999 8910	37
24	·010 4718	·010 4724	95·489	·999 9452	·014 8348	·014 8364	67·402	·999 8900	36
25	0·010 5445	0·010 5451	94·831	0·999 9444	0·014 9075	0·014 9091	67·073	0·999 8889	35
26	·010 6172	·010 6178	94·181	·999 9436	·014 9802	·014 9819	66·747	·999 8878	34
27	·010 6899	·010 6905	93·541	·999 9429	·015 0529	·015 0546	66·425	·999 8867	33
28	·010 7627	·010 7633	92·908	·999 9421	·015 1256	·015 1273	66·105	·999 8856	32
29	·010 8354	·010 8360	92·285	·999 9413	·015 1983	·015 2001	65·789	·999 8845	31
30	0·010 9081	0·010 9087	91·670	0·999 9405	0·015 2710	0·015 2728	65·476	0·999 8834	30
31	·010 9808	·010 9815	91·062	·999 9397	·015 3438	·015 3456	65·165	·999 8823	29
32	·011 0535	·011 0542	90·463	·999 9389	·015 4165	·015 4183	64·858	·999 8812	28
33	·011 1262	·011 1269	89·872	·999 9381	·015 4892	·015 4910	64·553	·999 8800	27
34	·011 1990	·011 1997	89·288	·999 9373	·015 5619	·015 5638	64·252	·999 8789	26
35	0·011 2717	0·011 2724	88·712	0·999 9365	0·015 6346	0·015 6365	63·953	0·999 8778	25
36	·011 3444	·011 3451	88·144	·999 9357	·015 7073	·015 7093	63·657	·999 8766	24
37	·011 4171	·011 4179	87·582	·999 9348	·015 7800	·015 7820	63·363	·999 8755	23
38	·011 4898	·011 4906	87·028	·999 9340	·015 8527	·015 8547	63·073	·999 8743	22
39	·011 5625	·011 5633	86·480	·999 9332	·015 9255	·015 9275	62·785	·999 8732	21
40	0·011 6353	0·011 6361	85·940	0·999 9323	0·015 9982	0·016 0002	62·499	0·999 8720	20
41	·011 7080	·011 7088	85·406	·999 9315	·016 0709	·016 0730	62·216	·999 8709	19
42	·011 7807	·011 7815	84·879	·999 9306	·016 1436	·016 1457	61·936	·999 8697	18
43	·011 8534	·011 8542	84·358	·999 9297	·016 2163	·016 2184	61·658	·999 8685	17
44	·011 9261	·011 9270	83·844	·999 9289	·016 2890	·016 2912	61·383	·999 8673	16
45	0·011 9989	0·011 9997	83·335	0·999 9280	0·016 3617	0·016 3639	61·110	0·999 8661	15
46	·012 0716	·012 0724	82·833	·999 9271	·016 4344	·016 4367	60·840	·999 8649	14
47	·012 1443	·012 1452	82·337	·999 9263	·016 5072	·016 5094	60·572	·999 8637	13
48	·012 2170	·012 2179	81·847	·999 9254	·016 5799	·016 5821	60·306	·999 8625	12
49	·012 2897	·012 2906	81·363	·999 9245	·016 6526	·016 6549	60·042	·999 8613	11
50	0·012 3624	0·012 3634	80·884	0·999 9236	0·016 7253	0·016 7276	59·781	0·999 8601	10
51	·012 4352	·012 4361	80·411	·999 9227	·016 7980	·016 8004	59·522	·999 8589	09
52	·012 5079	·012 5088	79·943	·999 9218	·016 8707	·016 8731	59·266	·999 8577	08
53	·012 5806	·012 5816	79·481	·999 9209	·016 9434	·016 9459	59·011	·999 8564	07
54	·012 6533	·012 6543	79·024	·999 9199	·017 0161	·017 0186	58·759	·999 8552	06
55	0·012 7260	0·012 7270	78·573	0·999 9190	0·017 0889	0·017 0913	58·509	0·999 8540	05
56	·012 7987	·012 7998	78·126	·999 9181	·017 1616	·017 1641	58·261	·999 8527	04
57	·012 8714	·012 8725	77·685	·999 9172	·017 2343	·017 2368	58·015	·999 8515	03
58	·012 9442	·012 9452	77·248	·999 9162	·017 3070	·017 3096	57·771	·999 8502	02
59	·013 0169	·013 0180	76·817	·999 9153	·017 3797	·017 3823	57·530	·999 8490	01
60	0·013 0896	0·013 0907	76·390	0·999 9143	0·017 4524	0·017 4551	57·290	0·999 8477	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	727–728	728–727	427–947	10–6	727–728	728–727	240–422	13–9	d

$5^{h}\ 57^{m}$ — $5^{h}\ 56^{m}$

$0^h\ 04^m$ $0^h\ 05^m$

d	728–727	727–728	2378–1533	12–16	728–726	727–728	1524–1064	16–19	d
	sin	tan	cot	cos	sin	tan	cot	cos	
s									
00	0·017 4524	0·017 4551	57·2900	0·999 8477	0·021 8149	0·021 8201	45·8294	0·999 7620	60
01	·017 5251	·017 5278	57·0522	·999 8464	·021 8876	·021 8928	45·6770	·999 7604	59
02	·017 5978	·017 6006	56·8164	·999 8451	·021 9603	·021 9656	45·5257	·999 7588	58
03	·017 6705	·017 6733	56·5825	·999 8439	·022 0330	·022 0383	45·3755	·999 7572	57
04	·017 7432	·017 7460	56·3506	·999 8426	·022 1057	·022 1111	45·2261	·999 7556	56
05	0·017 8160	0·017 8188	56·1205	0·999 8413	0·022 1784	0·022 1839	45·0778	0·999 7540	55
06	·017 8887	·017 8915	55·8924	·999 8400	·022 2511	·022 2566	44·9304	·999 7524	54
07	·017 9614	·017 9643	55·6660	·999 8387	·022 3238	·022 3294	44·7840	·999 7508	53
08	·018 0341	·018 0370	55·4415	·999 8374	·022 3965	·022 4021	44·6386	·999 7492	52
09	·018 1068	·018 1098	55·2188	·999 8361	·022 4692	·022 4749	44·4941	·999 7475	51
10	0·018 1795	0·018 1825	54·9979	0·999 8347	0·022 5419	0·022 5477	44·3505	0·999 7459	50
11	·018 2522	·018 2553	54·7787	·999 8334	·022 6146	·022 6204	44·2079	·999 7443	49
12	·018 3249	·018 3280	54·5613	·999 8321	·022 6873	·022 6932	44·0661	·999 7426	48
13	·018 3976	·018 4008	54·3456	·999 8307	·022 7600	·022 7659	43·9253	·999 7410	47
14	·018 4704	·018 4735	54·1316	·999 8294	·022 8327	·022 8387	43·7853	·999 7393	46
15	0·018 5431	0·018 5462	53·9193	0·999 8281	0·022 9054	0·022 9115	43·6463	0·999 7376	45
16	·018 6158	·018 6190	53·7086	·999 8267	·022 9781	·022 9842	43·5081	·999 7360	44
17	·018 6885	·018 6917	53·4996	·999 8254	·023 0508	·023 0570	43·3708	·999 7343	43
18	·018 7612	·018 7645	53·2921	·999 8240	·023 1236	·023 1297	43·2344	·999 7326	42
19	·018 8339	·018 8372	53·0863	·999 8226	·023 1963	·023 2025	43·0988	·999 7309	41
20	0·018 9066	0·018 9100	52·8821	0·999 8213	0·023 2690	0·023 2753	42·9641	0·999 7292	40
21	·018 9793	·018 9827	52·6794	·999 8199	·023 3417	·023 3480	42·8302	·999 7275	39
22	·019 0520	·019 0555	52·4783	·999 8185	·023 4144	·023 4208	42·6971	·999 7258	38
23	·019 1247	·019 1282	52·2787	·999 8171	·023 4871	·023 4935	42·5649	·999 7241	37
24	·019 1974	·019 2010	52·0807	·999 8157	·023 5598	·023 5663	42·4335	·999 7224	36
25	0·019 2702	0·019 2737	51·8841	0·999 8143	0·023 6325	0·023 6391	42·3029	0·999 7207	35
26	·019 3429	·019 3465	51·6890	·999 8129	·023 7052	·023 7118	42·1730	·999 7190	34
27	·019 4156	·019 4192	51·4954	·999 8115	·023 7779	·023 7846	42·0440	·999 7173	33
28	·019 4883	·019 4920	51·3032	·999 8101	·023 8506	·023 8574	41·9158	·999 7155	32
29	·019 5610	·019 5647	51·1124	·999 8087	·023 9233	·023 9301	41·7883	·999 7138	31
30	0·019 6337	0·019 6375	50·9230	0·999 8072	0·023 9960	0·024 0029	41·6617	0·999 7121	30
31	·019 7064	·019 7102	50·7351	·999 8058	·024 0687	·024 0756	41·5357	·999 7103	29
32	·019 7791	·019 7830	50·5485	·999 8044	·024 1414	·024 1484	41·4106	·999 7086	28
33	·019 8518	·019 8557	50·3633	·999 8029	·024 2141	·024 2212	41·2862	·999 7068	27
34	·019 9245	·019 9285	50·1794	·999 8015	·024 2868	·024 2939	41·1625	·999 7050	26
35	0·019 9972	0·020 0012	49·9969	0·999 8000	0·024 3595	0·024 3667	41·0396	0·999 7033	25
36	·020 0699	·020 0740	49·8157	·999 7986	·024 4322	·024 4395	40·9174	·999 7015	24
37	·020 1426	·020 1467	49·6358	·999 7971	·024 5049	·024 5122	40·7959	·999 6997	23
38	·020 2154	·020 2195	49·4572	·999 7956	·024 5776	·024 5850	40·6752	·999 6979	22
39	·020 2881	·020 2922	49·2799	·999 7942	·024 6503	·024 6578	40·5552	·999 6961	21
40	0·020 3608	0·020 3650	49·1039	0·999 7927	0·024 7230	0·024 7305	40·4358	0·999 6943	20
41	·020 4335	·020 4377	48·9291	·999 7912	·024 7957	·024 8033	40·3172	·999 6925	19
42	·020 5062	·020 5105	48·7555	·999 7897	·024 8684	·024 8761	40·1993	·999 6907	18
43	·020 5789	·020 5832	48·5832	·999 7882	·024 9411	·024 9488	40·0820	·999 6889	17
44	·020 6516	·020 6560	48·4121	·999 7867	·025 0138	·025 0216	39·9655	·999 6871	16
45	0·020 7243	0·020 7288	48·2422	0·999 7852	0·025 0865	0·025 0944	39·8496	0·999 6853	15
46	·020 7970	·020 8015	48·0734	·999 7837	·025 1592	·025 1671	39·7343	·999 6835	14
47	·020 8697	·020 8743	47·9059	·999 7822	·025 2319	·025 2399	39·6198	·999 6816	13
48	·020 9424	·020 9470	47·7395	·999 7807	·025 3046	·025 3127	39·5059	·999 6798	12
49	·021 0151	·021 0198	47·5743	·999 7792	·025 3773	·025 3854	39·3926	·999 6779	11
50	0·021 0878	0·021 0925	47·4102	0·999 7776	0·025 4500	0·025 4582	39·2800	0·999 6761	10
51	·021 1605	·021 1653	47·2472	·999 7761	·025 5227	·025 5310	39·1681	·999 6742	09
52	·021 2332	·021 2380	47·0853	·999 7745	·025 5954	·025 6038	39·0568	·999 6724	08
53	·021 3059	·021 3108	46·9246	·999 7730	·025 6681	·025 6765	38·9461	·999 6705	07
54	·021 3787	·021 3835	46·7649	·999 7715	·025 7408	·025 7493	38·8360	·999 6687	06
55	0·021 4514	0·021 4563	46·6064	0·999 7699	0·025 8135	0·025 8221	38·7266	0·999 6668	05
56	·021 5241	·021 5291	46·4489	·999 7683	·025 8862	·025 8948	38·6177	·999 6649	04
57	·021 5968	·021 6018	46·2924	·999 7668	·025 9589	·025 9676	38·5095	·999 6630	03
58	·021 6695	·021 6746	46·1370	·999 7652	·026 0316	·026 0404	38·4019	·999 6611	02
59	·021 7422	·021 7473	45·9827	·999 7636	·026 1043	·026 1131	38·2949	·999 6592	01
60	0·021 8149	0·021 8201	45·8294	0·999 7620	0·026 1769	0·026 1859	38·1885	0·999 6573	00
									s
	cos	cot	tan	sin	cos	cot	tan	sin	
d	727–728	728–727	1533–2378	16–12	726–728	728–727	1064–1524	19–16	d

$5^h\ 55^m$ $5^h\ 54^m$

$0^h\ 06^m$ $0^h\ 07^m$

d	727–726	727–728	1059–781	19–22	727–726	727–729	778–598	22–26	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·026 1769	0·026 1859	38·1885	0·999 6573	0·030 5385	0·030 5528	32·7303	0·999 5336	60
01	·026 2496	·026 2587	38·0826	·999 6554	·030 6112	·030 6256	32·6525	·999 5314	59
02	·026 3223	·026 3315	37·9774	·999 6535	·030 6839	·030 6983	32·5750	·999 5291	58
03	·026 3950	·026 4042	37·8727	·999 6516	·030 7566	·030 7711	32·4980	·999 5269	57
04	·026 4677	·026 4770	37·7686	·999 6497	·030 8293	·030 8439	32·4213	·999 5247	56
05	0·026 5404	0·026 5498	37·6651	0·999 6477	0·030 9020	0·030 9167	32·3450	0·999 5224	55
06	·026 6131	·026 6226	37·5621	·999 6458	·030 9746	·030 9895	32·2690	·999 5202	54
07	·026 6858	·026 6953	37·4597	·999 6439	·031 0473	·031 0623	32·1934	·999 5179	53
08	·026 7585	·026 7681	37·3579	·999 6419	·031 1200	·031 1351	32·1181	·999 5157	52
09	·026 8312	·026 8409	37·2566	·999 6400	·031 1927	·031 2079	32·0432	·999 5134	51
10	0·026 9039	0·026 9137	37·1559	0·999 6380	0·031 2654	0·031 2807	31·9686	0·999 5111	50
11	·026 9766	·026 9864	37·0557	·999 6361	·031 3381	·031 3535	31·8944	·999 5088	49
12	·027 0493	·027 0592	36·9560	·999 6341	·031 4108	·031 4263	31·8205	·999 5066	48
13	·027 1220	·027 1320	36·8569	·999 6321	·031 4834	·031 4991	31·7470	·999 5043	47
14	·027 1947	·027 2048	36·7583	·999 6302	·031 5561	·031 5719	31·6738	·999 5020	46
15	0·027 2674	0·027 2775	36·6602	0·999 6282	0·031 6288	0·031 6446	31·6009	0·999 4997	45
16	·027 3401	·027 3503	36·5627	·999 6262	·031 7015	·031 7174	31·5284	·999 4974	44
17	·027 4128	·027 4231	36·4656	·999 6242	·031 7742	·031 7902	31·4562	·999 4951	43
18	·027 4855	·027 4959	36·3691	·999 6222	·031 8469	·031 8630	31·3843	·999 4928	42
19	·027 5582	·027 5686	36·2731	·999 6202	·031 9196	·031 9358	31·3128	·999 4904	41
20	0·027 6309	0·027 6414	36·1776	0·999 6182	0·031 9922	0·032 0086	31·2416	0·999 4881	40
21	·027 7036	·027 7142	36·0826	·999 6162	·032 0649	·032 0814	31·1707	·999 4858	39
22	·027 7763	·027 7870	35·9881	·999 6142	·032 1376	·032 1542	31·1001	·999 4835	38
23	·027 8489	·027 8598	35·8941	·999 6121	·032 2103	·032 2270	31·0299	·999 4811	37
24	·027 9216	·027 9325	35·8006	·999 6101	·032 2830	·032 2998	30·9599	·999 4788	36
25	0·027 9943	0·028 0053	35·7075	0·999 6081	0·032 3557	0·032 3726	30·8903	0·999 4764	35
26	·028 0670	·028 0781	35·6150	·999 6060	·032 4283	·032 4454	30·8210	·999 4741	34
27	·028 1397	·028 1509	35·5229	·999 6040	·032 5010	·032 5182	30·7520	·999 4717	33
28	·028 2124	·028 2236	35·4313	·999 6020	·032 5737	·032 5910	30·6833	·999 4693	32
29	·028 2851	·028 2964	35·3402	·999 5999	·032 6464	·032 6638	30·6149	·999 4670	31
30	0·028 3578	0·028 3692	35·2495	0·999 5978	0·032 7191	0·032 7366	30·5468	0·999 4646	30
31	·028 4305	·028 4420	35·1593	·999 5958	·032 7918	·032 8094	30·4791	·999 4622	29
32	·028 5032	·028 5148	35·0695	·999 5937	·032 8644	·032 8822	30·4116	·999 4598	28
33	·028 5759	·028 5876	34·9803	·999 5916	·032 9371	·032 9550	30·3444	·999 4574	27
34	·028 6486	·028 6603	34·8914	·999 5895	·033 0098	·033 0278	30·2775	·999 4550	26
35	0·028 7213	0·028 7331	34·8030	0·999 5875	0·033 0825	0·033 1006	30·2109	0·999 4526	25
36	·028 7940	·028 8059	34·7151	·999 5854	·033 1552	·033 1734	30·1446	·999 4502	24
37	·028 8666	·028 8787	34·6276	·999 5833	·033 2279	·033 2462	30·0786	·999 4478	23
38	·028 9393	·028 9515	34·5406	·999 5812	·033 3005	·033 3190	30·0129	·999 4454	22
39	·029 0120	·029 0242	34·4540	·999 5791	·033 3732	·033 3918	29·9475	·999 4430	21
40	0·029 0847	0·029 0970	34·3678	0·999 5770	0·033 4459	0·033 4646	29·8823	0·999 4405	20
41	·029 1574	·029 1698	34·2820	·999 5748	·033 5186	·033 5374	29·8174	·999 4381	19
42	·029 2301	·029 2426	34·1967	·999 5727	·033 5913	·033 6102	29·7528	·999 4357	18
43	·029 3028	·029 3154	34·1118	·999 5706	·033 6639	·033 6830	29·6885	·999 4332	17
44	·029 3755	·029 3882	34·0273	·999 5684	·033 7366	·033 7558	29·6245	·999 4308	16
45	0·029 4482	0·029 4610	33·9432	0·999 5663	0·033 8093	0·033 8286	29·5607	0·999 4283	15
46	·029 5209	·029 5337	33·8596	·999 5642	·033 8820	·033 9015	29·4973	·999 4258	14
47	·029 5936	·029 6065	33·7763	·999 5620	·033 9547	·033 9743	29·4340	·999 4234	13
48	·029 6662	·029 6793	33·6935	·999 5599	·034 0274	·034 0471	29·3711	·999 4209	12
49	·029 7389	·029 7521	33·6111	·999 5577	·034 1000	·034 1199	29·3084	·999 4184	11
50	0·029 8116	0·029 8249	33·5291	0·999 5555	0·034 1727	0·034 1927	29·2460	0·999 4159	10
51	·029 8843	·029 8977	33·4474	·999 5534	·034 2454	·034 2655	29·1839	·999 4135	09
52	·029 9570	·029 9705	33·3662	·999 5512	·034 3181	·034 3383	29·1220	·999 4110	08
53	·030 0297	·030 0432	33·2854	·999 5490	·034 3907	·034 4111	29·0604	·999 4085	07
54	·030 1024	·030 1160	33·2049	·999 5468	·034 4634	·034 4839	28·9990	·999 4060	06
55	0·030 1751	0·030 1888	33·1248	0·999 5446	0·034 5361	0·034 5567	28·9379	0·999 4035	05
56	·030 2478	·030 2616	33·0452	·999 5424	·034 6088	·034 6295	28·8771	·999 4009	04
57	·030 3204	·030 3344	32·9659	·999 5402	·034 6815	·034 7023	28·8165	·999 3984	03
58	·030 3931	·030 4072	32·8870	·999 5380	·034 7541	·034 7751	28·7562	·999 3959	02
59	·030 4658	·030 4800	32·8084	·999 5358	·034 8268	·034 8480	28·6961	·999 3934	01
60	0·030 5385	0·030 5528	32·7303	0·999 5336	0·034 8995	0·034 9208	28·6363	0·999 3908	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	726–727	728–727	781–1059	22–19	726–727	729–727	598–778	26–22	d

$5^h\ 53^m$ $5^h\ 52^m$

$0^h\ 08^m$ $0^h\ 09^m$

d	727–726	728–729	596–473	25–29	727–726	728–729	471–383	28–32	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·034 8995	0·034 9208	28·6363	0·999 3908	0·039 2598	0·039 2901	25·4517	0·999 2290	60
01	·034 9722	·034 9936	28·5767	·999 3883	·039 3325	·039 3629	25·4046	·999 2262	59
02	·035 0449	·035 0664	28·5173	·999 3857	·039 4051	·039 4358	25·3577	·999 2233	58
03	·035 1175	·035 1392	28·4582	·999 3832	·039 4778	·039 5086	25·3109	·999 2204	57
04	·035 1902	·035 2120	28·3994	·999 3806	·039 5505	·039 5814	25·2644	·999 2176	56
05	0·035 2629	0·035 2848	28·3408	0·999 3781	0·039 6231	0·039 6543	25·2180	0·999 2147	55
06	·035 3356	·035 3576	28·2824	·999 3755	·039 6958	·039 7271	25·1717	·999 2118	54
07	·035 4082	·035 4305	28·2243	·999 3729	·039 7685	·039 8000	25·1257	·999 2089	53
08	·035 4809	·035 5033	28·1664	·999 3704	·039 8411	·039 8728	25·0798	·999 2060	52
09	·035 5536	·035 5761	28·1088	·999 3678	·039 9138	·039 9456	25·0340	·999 2031	51
10	0·035 6263	0·035 6489	28·0514	0·999 3652	0·039 9865	0·040 0185	24·9885	0·999 2002	50
11	·035 6989	·035 7217	27·9942	·999 3626	·040 0591	·040 0913	24·9431	·999 1973	49
12	·035 7716	·035 7945	27·9372	·999 3600	·040 1318	·040 1641	24·8978	·999 1944	48
13	·035 8443	·035 8673	27·8805	·999 3574	·040 2045	·040 2370	24·8528	·999 1915	47
14	·035 9170	·035 9402	27·8240	·999 3548	·040 2771	·040 3098	24·8078	·999 1885	46
15	0·035 9896	0·036 0130	27·7678	0·999 3522	0·040 3498	0·040 3827	24·7631	0·999 1856	45
16	·036 0623	·036 0858	27·7117	·999 3495	·040 4224	·040 4555	24·7185	·999 1827	44
17	·036 1350	·036 1586	27·6559	·999 3469	·040 4951	·040 5284	24·6741	·999 1797	43
18	·036 2077	·036 2314	27·6004	·999 3443	·040 5678	·040 6012	24·6298	·999 1768	42
19	·036 2803	·036 3042	27·5450	·999 3417	·040 6404	·040 6740	24·5857	·999 1738	41
20	0·036 3530	0·036 3771	27·4899	0·999 3390	0·040 7131	0·040 7469	24·5418	0·999 1709	40
21	·036 4257	·036 4499	27·4349	·999 3364	·040 7858	·040 8197	24·4980	·999 1679	39
22	·036 4984	·036 5227	27·3802	·999 3337	·040 8584	·040 8926	24·4543	·999 1649	38
23	·036 5710	·036 5955	27·3258	·999 3311	·040 9311	·040 9654	24·4108	·999 1620	37
24	·036 6437	·036 6683	27·2715	·999 3284	·041 0037	·041 0383	24·3675	·999 1590	36
25	0·036 7164	0·036 7412	27·2174	0·999 3257	0·041 0764	0·041 1111	24·3243	0·999 1560	35
26	·036 7891	·036 8140	27·1636	·999 3231	·041 1491	·041 1839	24·2813	·999 1530	34
27	·036 8617	·036 8868	27·1100	·999 3204	·041 2217	·041 2568	24·2384	·999 1500	33
28	·036 9344	·036 9596	27·0566	·999 3177	·041 2944	·041 3296	24·1957	·999 1470	32
29	·037 0071	·037 0324	27·0034	·999 3150	·041 3670	·041 4025	24·1531	·999 1440	31
30	0·037 0797	0·037 1053	26·9504	0·999 3123	0·041 4397	0·041 4753	24·1107	0·999 1410	30
31	·037 1524	·037 1781	26·8976	·999 3096	·041 5124	·041 5482	24·0684	·999 1380	29
32	·037 2251	·037 2509	26·8450	·999 3069	·041 5850	·041 6210	24·0263	·999 1350	28
33	·037 2978	·037 3237	26·7926	·999 3042	·041 6577	·041 6939	23·9843	·999 1319	27
34	·037 3704	·037 3966	26·7404	·999 3015	·041 7303	·041 7667	23·9425	·999 1289	26
35	0·037 4431	0·037 4694	26·6885	0·999 2988	0·041 8030	0·041 8396	23·9008	0·999 1259	25
36	·037 5158	·037 5422	26·6367	·999 2960	·041 8757	·041 9124	23·8593	·999 1228	24
37	·037 5884	·037 6150	26·5851	·999 2933	·041 9483	·041 9853	23·8179	·999 1198	23
38	·037 6611	·037 6879	26·5337	·999 2906	·042 0210	·042 0581	23·7766	·999 1167	22
39	·037 7338	·037 7607	26·4826	·999 2878	·042 0936	·042 1310	23·7355	·999 1137	21
40	0·037 8065	0·037 8335	26·4316	0·999 2851	0·042 1663	0·042 2038	23·6945	0·999 1106	20
41	·037 8791	·037 9063	26·3808	·999 2823	·042 2389	·042 2767	23·6537	·999 1075	19
42	·037 9518	·037 9792	26·3302	·999 2796	·042 3116	·042 3495	23·6130	·999 1045	18
43	·038 0245	·038 0520	26·2798	·999 2768	·042 3843	·042 4224	23·5725	·999 1014	17
44	·038 0971	·038 1248	26·2296	·999 2740	·042 4569	·042 4952	23·5321	·999 0983	16
45	0·038 1698	0·038 1976	26·1796	0·999 2713	0·042 5296	0·042 5681	23·4918	0·999 0952	15
46	·038 2425	·038 2705	26·1298	·999 2685	·042 6022	·042 6409	23·4516	·999 0921	14
47	·038 3151	·038 3433	26·0802	·999 2657	·042 6749	·042 7138	23·4116	·999 0890	13
48	·038 3878	·038 4161	26·0307	·999 2629	·042 7475	·042 7866	23·3718	·999 0859	12
49	·038 4605	·038 4890	25·9815	·999 2601	·042 8202	·042 8595	23·3320	·999 0828	11
50	0·038 5331	0·038 5618	25·9324	0·999 2573	0·042 8928	0·042 9324	23·2925	0·999 0797	10
51	·038 6058	·038 6346	25·8835	·999 2545	·042 9655	·043 0052	23·2530	·999 0766	09
52	·038 6785	·038 7074	25·8348	·999 2517	·043 0382	·043 0781	23·2137	·999 0734	08
53	·038 7511	·038 7803	25·7863	·999 2489	·043 1108	·043 1509	23·1745	·999 0703	07
54	·038 8238	·038 8531	25·7380	·999 2461	·043 1835	·043 2238	23·1354	·999 0672	06
55	0·038 8965	0·038 9259	25·6898	0·999 2432	0·043 2561	0·043 2966	23·0965	0·999 0640	05
56	·038 9692	·038 9988	25·6418	·999 2404	·043 3288	·043 3695	23·0577	·999 0609	04
57	·039 0418	·039 0716	25·5940	·999 2376	·043 4014	·043 4424	23·0190	·999 0577	03
58	·039 1145	·039 1444	25·5464	·999 2347	·043 4741	·043 5152	22·9805	·999 0546	02
59	·039 1871	·039 2173	25·4990	·999 2319	·043 5467	·043 5881	22·9421	·999 0514	01
60	0·039 2598	0·039 2901	25·4517	0·999 2290	0·043 6194	0·043 6609	22·9038	0·999 0482	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	726–727	729–728	473–596	29–25	726–727	729–728	383–471	32–28	d

$5^h\ 51^m$ $5^h\ 50^m$

0^h 10^m | 0^h 11^m

d	727–726	728–729	382–317	31–35	727–726	728–730	315–266	35–38	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·043 6194	0·043 6609	22·9038	0·999 0482	0·047 9781	0·048 0334	20·8188	0·998 8484	60
01	·043 6920	·043 7338	22·8656	·999 0450	·048 0508	·048 1063	20·7873	·998 8449	59
02	·043 7647	·043 8067	22·8276	·999 0419	·048 1234	·048 1792	20·7558	·998 8414	58
03	·043 8373	·043 8795	22·7897	·999 0387	·048 1960	·048 2521	20·7245	·998 8379	57
04	·043 9100	·043 9524	22·7519	·999 0355	·048 2687	·048 3250	20·6932	·998 8344	56
05	0·043 9826	0·044 0253	22·7142	0·999 0323	0·048 3413	0·048 3979	20·6621	0·998 8309	55
06	·044 0553	·044 0981	22·6767	·999 0291	·048 4140	·048 4708	20·6310	·998 8274	54
07	·044 1280	·044 1710	22·6393	·999 0259	·048 4866	·048 5437	20·6000	·998 8238	53
08	·044 2006	·044 2438	22·6020	·999 0227	·048 5592	·048 6166	20·5691	·998 8203	52
09	·044 2733	·044 3167	22·5649	·999 0195	·048 6319	·048 6895	20·5383	·998 8168	51
10	0·044 3459	0·044 3896	22·5278	0·999 0162	0·048 7045	0·048 7624	20·5076	0·998 8132	50
11	·044 4186	·044 4624	22·4909	·999 0130	·048 7771	·048 8353	20·4770	·998 8097	49
12	·044 4912	·044 5353	22·4541	·999 0098	·048 8498	·048 9082	20·4465	·998 8061	48
13	·044 5639	·044 6082	22·4174	·999 0065	·048 9224	·048 9811	20·4161	·998 8026	47
14	·044 6365	·044 6810	22·3809	·999 0033	·048 9950	·049 0540	20·3857	·998 7990	46
15	0·044 7092	0·044 7539	22·3444	0·999 0000	0·049 0677	0·049 1268	20·3555	0·998 7955	45
16	·044 7818	·044 8268	22·3081	·998 9968	·049 1403	·049 1997	20·3253	·998 7919	44
17	·044 8545	·044 8996	22·2719	·998 9935	·049 2129	·049 2726	20·2952	·998 7883	43
18	·044 9271	·044 9725	22·2358	·998 9903	·049 2856	·049 3455	20·2653	·998 7847	42
19	·044 9997	·045 0454	22·1998	·998 9870	·049 3582	·049 4184	20·2354	·998 7811	41
20	0·045 0724	0·045 1183	22·1640	0·998 9837	0·049 4308	0·049 4913	20·2056	0·998 7775	40
21	·045 1450	·045 1911	22·1282	·998 9804	·049 5035	·049 5642	20·1758	·998 7740	39
22	·045 2177	·045 2640	22·0926	·998 9772	·049 5761	·049 6371	20·1462	·998 7703	38
23	·045 2903	·045 3369	22·0571	·998 9739	·049 6487	·049 7100	20·1167	·998 7667	37
24	·045 3630	·045 4097	22·0217	·998 9706	·049 7214	·049 7829	20·0872	·998 7631	36
25	0·045 4356	0·045 4826	21·9864	0·998 9673	0·049 7940	0·049 8559	20·0578	0·998 7595	35
26	·045 5083	·045 5555	21·9513	·998 9640	·049 8666	·049 9288	20·0285	·998 7559	34
27	·045 5809	·045 6284	21·9162	·998 9606	·049 9393	·050 0017	19·9993	·998 7523	33
28	·045 6536	·045 7012	21·8813	·998 9573	·050 0119	·050 0746	19·9702	·998 7486	32
29	·045 7262	·045 7741	21·8464	·998 9540	·050 0845	·050 1475	19·9412	·998 7450	31
30	0·045 7989	0·045 8470	21·8117	0·998 9507	0·050 1572	0·050 2204	19·9122	0·998 7413	30
31	·045 8715	·045 9199	21·7771	·998 9473	·050 2298	·050 2933	19·8834	·998 7377	29
32	·045 9442	·045 9927	21·7426	·998 9440	·050 3024	·050 3662	19·8546	·998 7340	28
33	·046 0168	·046 0656	21·7082	·998 9407	·050 3751	·050 4391	19·8259	·998 7304	27
34	·046 0894	·046 1385	21·6739	·998 9373	·050 4477	·050 5120	19·7973	·998 7267	26
35	0·046 1621	0·046 2114	21·6397	0·998 9340	0·050 5203	0·050 5849	19·7687	0·998 7230	25
36	·046 2347	·046 2842	21·6056	·998 9306	·050 5929	·050 6578	19·7403	·998 7194	24
37	·046 3074	·046 3571	21·5717	·998 9272	·050 6656	·050 7307	19·7119	·998 7157	23
38	·046 3800	·046 4300	21·5378	·998 9239	·050 7382	·050 8036	19·6836	·998 7120	22
39	·046 4527	·046 5029	21·5040	·998 9205	·050 8108	·050 8765	19·6554	·998 7083	21
40	0·046 5253	0·046 5757	21·4704	0·998 9171	0·050 8835	0·050 9495	19·6273	0·998 7046	20
41	·046 5980	·046 6486	21·4369	·998 9137	·050 9561	·051 0224	19·5992	·998 7009	19
42	·046 6706	·046 7215	21·4034	·998 9103	·051 0287	·051 0953	19·5713	·998 6972	18
43	·046 7432	·046 7944	21·3701	·998 9069	·051 1013	·051 1682	19·5434	·998 6935	17
44	·046 8159	·046 8673	21·3369	·998 9035	·051 1740	·051 2411	19·5156	·998 6898	16
45	0·046 8885	0·046 9402	21·3037	0·998 9001	0·051 2466	0·051 3140	19·4879	0·998 6860	15
46	·046 9612	·047 0130	21·2707	·998 8967	·051 3192	·051 3869	19·4602	·998 6823	14
47	·047 0338	·047 0859	21·2378	·998 8933	·051 3918	·051 4598	19·4326	·998 6786	13
48	·047 1065	·047 1588	21·2049	·998 8899	·051 4645	·051 5328	19·4051	·998 6748	12
49	·047 1791	·047 2317	21·1722	·998 8864	·051 5371	·051 6057	19·3777	·998 6711	11
50	0·047 2517	0·047 3046	21·1396	0·998 8830	0·051 6097	0·051 6786	19·3504	0·998 6673	10
51	·047 3244	·047 3775	21·1071	·998 8796	·051 6823	·051 7515	19·3231	·998 6636	09
52	·047 3970	·047 4503	21·0747	·998 8761	·051 7550	·051 8244	19·2959	·998 6598	08
53	·047 4697	·047 5232	21·0423	·998 8727	·051 8276	·051 8973	19·2688	·998 6560	07
54	·047 5423	·047 5961	21·0101	·998 8692	·051 9002	·051 9703	19·2418	·998 6523	06
55	0·047 6149	0·047 6690	20·9780	0·998 8658	0·051 9728	0·052 0432	19·2148	0·998 6485	05
56	·047 6876	·047 7419	20·9460	·998 8623	·052 0455	·052 1161	19·1879	·998 6447	04
57	·047 7602	·047 8148	20·9140	·998 8588	·052 1181	·052 1890	19·1611	·998 6409	03
58	·047 8329	·047 8877	20·8822	·998 8554	·052 1907	·052 2619	19·1344	·998 6371	02
59	·047 9055	·047 9606	20·8505	·998 8519	·052 2633	·052 3349	19·1077	·998 6333	01
60	0·047 9781	0·048 0334	20·8188	0·998 8484	0·052 3360	0·052 4078	19·0811	0·998 6295	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	726–727	729–728	317–382	35–31	726–727	730–728	266–315	38–35	d

5^h 49^m | 5^h 48^m

0ʰ 12ᵐ 0ʰ 13ᵐ

d	727–726	729–730	2652–2265	38–41	726–725	729–730	2260–1953	41–45	d
	sin	tan	cot	cos	sin	tan	cot	cos	
s									
00	0·052 3360	0·052 4078	19·08114	0·998 6295	0·056 6928	0·056 7841	17·61056	0·998 3917	60
01	·052 4086	·052 4807	·05462	·998 6257	·056 7654	·056 8571	·58796	·998 3875	59
02	·052 4812	·052 5536	·02818	·998 6219	·056 8380	·056 9300	·56542	·998 3834	58
03	·052 5538	·052 6265	19·00182	·998 6181	·056 9106	·057 0030	·54294	·998 3793	57
04	·052 6264	·052 6995	18·97552	·998 6143	·056 9832	·057 0759	·52052	·998 3751	56
05	0·052 6991	0·052 7724	18·94930	0·998 6104	0·057 0558	0·057 1489	17·49815	0·998 3710	55
06	·052 7717	·052 8453	·92315	·998 6066	·057 1284	·057 2219	·47584	·998 3668	54
07	·052 8443	·052 9182	·89707	·998 6028	·057 2010	·057 2948	·45358	·998 3627	53
08	·052 9169	·052 9912	·87107	·998 5989	·057 2736	·057 3678	·43139	·998 3585	52
09	·052 9895	·053 0641	·84513	·998 5951	·057 3462	·057 4407	·40924	·998 3544	51
10	0·053 0622	0·053 1370	18·81927	0·998 5912	0·057 4188	0·057 5137	17·38716	0·998 3502	50
11	·053 1348	·053 2100	·79348	·998 5873	·057 4914	·057 5867	·36513	·998 3460	49
12	·053 2074	·053 2829	·76775	·998 5835	·057 5640	·057 6596	·34315	·998 3418	48
13	·053 2800	·053 3558	·74210	·998 5796	·057 6366	·057 7326	·32124	·998 3376	47
14	·053 3526	·053 4287	·71652	·998 5757	·057 7092	·057 8056	·29937	·998 3334	46
15	0·053 4253	0·053 5017	18·69101	0·998 5719	0·057 7818	0·057 8785	17·27756	0·998 3292	45
16	·053 4979	·053 5746	·66556	·998 5680	·057 8544	·057 9515	·25581	·998 3250	44
17	·053 5705	·053 6475	·64019	·998 5641	·057 9270	·058 0245	·23411	·998 3208	43
18	·053 6431	·053 7205	·61488	·998 5602	·057 9996	·058 0974	·21246	·998 3166	42
19	·053 7157	·053 7934	·58964	·998 5563	·058 0722	·058 1704	·19087	·998 3124	41
20	0·053 7883	0·053 8663	18·56447	0·998 5524	0·058 1448	0·058 2434	17·16934	0·998 3082	40
21	·053 8610	·053 9393	·53937	·998 5484	·058 2174	·058 3163	·14785	·998 3039	39
22	·053 9336	·054 0122	·51434	·998 5445	·058 2900	·058 3893	·12642	·998 2997	38
23	·054 0062	·054 0851	·48937	·998 5406	·058 3626	·058 4623	·10505	·998 2954	37
24	·054 0788	·054 1581	·46447	·998 5367	·058 4352	·058 5352	·08372	·998 2912	36
25	0·054 1514	0·054 2310	18·43964	0·998 5327	0·058 5078	0·058 6082	17·06245	0·998 2870	35
26	·054 2240	·054 3039	·41487	·998 5288	·058 5804	·058 6812	·04124	·998 2827	34
27	·054 2967	·054 3769	·39017	·998 5248	·058 6530	·058 7542	17·02007	·998 2784	33
28	·054 3693	·054 4498	·36554	·998 5209	·058 7256	·058 8271	16·99896	·998 2742	32
29	·054 4419	·054 5227	·34097	·998 5169	·058 7982	·058 9001	·97790	·998 2699	31
30	0·054 5145	0·054 5957	18·31647	0·998 5130	0·058 8708	0·058 9731	16·95689	0·998 2656	30
31	·054 5871	·054 6686	·29203	·998 5090	·058 9434	·059 0461	·93593	·998 2613	29
32	·054 6597	·054 7416	·26765	·998 5050	·059 0160	·059 1190	·91503	·998 2570	28
33	·054 7323	·054 8145	·24335	·998 5011	·059 0886	·059 1920	·89417	·998 2527	27
34	·054 8050	·054 8874	·21910	·998 4971	·059 1612	·059 2650	·87337	·998 2484	26
35	0·054 8776	0·054 9604	18·19492	0·998 4931	0·059 2338	0·059 3380	16·85262	0·998 2441	25
36	·054 9502	·055 0333	·17081	·998 4891	·059 3064	·059 4109	·83191	·998 2398	24
37	·055 0228	·055 1063	·14675	·998 4851	·059 3790	·059 4839	·81126	·998 2355	23
38	·055 0954	·055 1792	·12277	·998 4811	·059 4516	·059 5569	·79066	·998 2312	22
39	·055 1680	·055 2522	·09884	·998 4771	·059 5242	·059 6299	·77011	·998 2269	21
40	0·055 2406	0·055 3251	18·07498	0·998 4731	0·059 5967	0·059 7029	16·74961	0·998 2225	20
41	·055 3132	·055 3980	·05118	·998 4691	·059 6693	·059 7758	·72916	·998 2182	19
42	·055 3858	·055 4710	·02744	·998 4650	·059 7419	·059 8488	·70876	·998 2139	18
43	·055 4585	·055 5439	18·00376	·998 4610	·059 8145	·059 9218	·68841	·998 2095	17
44	·055 5311	·055 6169	17·98015	·998 4570	·059 8871	·059 9948	·66811	·998 2052	16
45	0·055 6037	0·055 6898	17·95660	0·998 4529	0·059 9597	0·060 0678	16·64786	0·998 2008	15
46	·055 6763	·055 7628	·93311	·998 4489	·060 0323	·060 1408	·62766	·998 1964	14
47	·055 7489	·055 8357	·90968	·998 4448	·060 1049	·060 2138	·60750	·998 1921	13
48	·055 8215	·055 9087	·88631	·998 4408	·060 1775	·060 2867	·58740	·998 1877	12
49	·055 8941	·055 9816	·86300	·998 4367	·060 2501	·060 3597	·56734	·998 1833	11
50	0·055 9667	0·056 0546	17·83976	0·998 4326	0·060 3227	0·060 4327	16·54733	0·998 1789	10
51	·056 0393	·056 1275	·81657	·998 4286	·060 3952	·060 5057	·52737	·998 1745	09
52	·056 1119	·056 2005	·79344	·998 4245	·060 4678	·060 5787	·50746	·998 1701	08
53	·056 1845	·056 2734	·77037	·998 4204	·060 5404	·060 6517	·48759	·998 1657	07
54	·056 2572	·056 3464	·74737	·998 4163	·060 6130	·060 7247	·46777	·998 1613	06
55	0·056 3298	0·056 4193	17·72442	0·998 4122	0·060 6856	0·060 7977	16·44800	0·998 1569	05
56	·056 4024	·056 4923	·70153	·998 4081	·060 7582	·060 8706	·42828	·998 1525	04
57	·056 4750	·056 5652	·67870	·998 4040	·060 8308	·060 9436	·40860	·998 1481	03
58	·056 5476	·056 6382	·65593	·998 3999	·060 9034	·061 0166	·38897	·998 1437	02
59	·056 6202	·056 7112	·63321	·998 3958	·060 9760	·061 0896	·36939	·998 1392	01
60	0·056 6928	0·056 7841	17·61056	0·998 3917	0·061 0485	0·061 1626	16·34986	0·998 1348	00
									s
	cos	cot	tan	sin	cos	cot	tan	sin	
d	726–727	730–729	2265–2652	41–38	725–726	730–729	1953–2260	45–41	d

5ʰ 47ᵐ 5ʰ 46ᵐ

$0^h\ 14^m$ $0^h\ 15^m$

d	726–725	730–731	1949–1702	44–48	726–725	730–731	1698–1496	47–51	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·061 0485	0·061 1626	16·34986	0·998 1348	0·065 4031	0·065 5435	15·25705	0·997 8589	60
01	·061 1211	·061 2356	·33037	·998 1304	·065 4757	·065 6165	·24007	·997 8542	59
02	·061 1937	·061 3086	·31092	·998 1259	·065 5483	·065 6895	·22313	·997 8494	58
03	·061 2663	·061 3816	·29153	·998 1215	·065 6208	·065 7626	·20622	·997 8446	57
04	·061 3389	·061 4546	·27217	·998 1170	·065 6934	·065 8356	·18935	·997 8399	56
05	0·061 4115	0·061 5276	16·25287	0·998 1125	0·065 7660	0·065 9086	15·17252	0·997 8351	55
06	·061 4841	·061 6006	·23361	·998 1081	·065 8385	·065 9817	·15572	·997 8303	54
07	·061 5566	·061 6736	·21439	·998 1036	·065 9111	·066 0547	·13896	·997 8255	53
08	·061 6292	·061 7466	·19523	·998 0991	·065 9836	·066 1278	·12224	·997 8207	52
09	·061 7018	·061 8196	·17610	·998 0946	·066 0562	·066 2008	·10556	·997 8159	51
10	0·061 7744	0·061 8926	16·15702	0·998 0901	0·066 1288	0·066 2738	15·08891	0·997 8111	50
11	·061 8470	·061 9656	·13799	·998 0856	·066 2013	·066 3469	·07230	·997 8063	49
12	·061 9196	·062 0386	·11900	·998 0811	·066 2739	·066 4199	·05572	·997 8015	48
13	·061 9921	·062 1116	·10005	·998 0766	·066 3465	·066 4930	·03918	·997 7966	47
14	·062 0647	·062 1846	·08115	·998 0721	·066 4190	·066 5660	·02268	·997 7918	46
15	0·062 1373	0·062 2576	16·06229	0·998 0676	0·066 4916	0·066 6391	15·00621	0·997 7870	45
16	·062 2099	·062 3306	·04348	·998 0631	·066 5641	·066 7121	14·98978	·997 7821	44
17	·062 2825	·062 4036	·02471	·998 0586	·066 6367	·066 7851	·97339	·997 7773	43
18	·062 3550	·062 4766	16·00599	·998 0540	·066 7093	·066 8582	·95703	·997 7725	42
19	·062 4276	·062 5496	15·98731	·998 0495	·066 7818	·066 9312	·94071	·997 7676	41
20	0·062 5002	0·062 6226	15·96867	0·998 0450	0·066 8544	0·067 0043	14·92442	0·997 7627	40
21	·062 5728	·062 6956	·95007	·998 0404	·066 9269	·067 0773	·90816	·997 7579	39
22	·062 6454	·062 7686	·93152	·998 0359	·066 9995	·067 1504	·89195	·997 7530	38
23	·062 7179	·062 8417	·91301	·998 0313	·067 0721	·067 2234	·87576	·997 7481	37
24	·062 7905	·062 9147	·89454	·998 0267	·067 1446	·067 2965	·85962	·997 7433	36
25	0·062 8631	0·062 9877	15·87612	0·998 0222	0·067 2172	0·067 3695	14·84350	0·997 7384	35
26	·062 9357	·063 0607	·85774	·998 0176	·067 2897	·067 4426	·82742	·997 7335	34
27	·063 0083	·063 1337	·83940	·998 0130	·067 3623	·067 5156	·81138	·997 7286	33
28	·063 0808	·063 2067	·82110	·998 0084	·067 4349	·067 5887	·79537	·997 7237	32
29	·063 1534	·063 2797	·80285	·998 0038	·067 5074	·067 6618	·77940	·997 7188	31
30	0·063 2260	0·063 3527	15·78464	0·997 9992	0·067 5800	0·067 7348	14·76346	0·997 7139	30
31	·063 2986	·063 4258	·76647	·997 9946	·067 6525	·067 8079	·74755	·997 7089	29
32	·063 3711	·063 4988	·74834	·997 9900	·067 7251	·067 8809	·73168	·997 7040	28
33	·063 4437	·063 5718	·73025	·997 9854	·067 7976	·067 9540	·71584	·997 6991	27
34	·063 5163	·063 6448	·71220	·997 9808	·067 8702	·068 0270	·70004	·997 6942	26
35	0·063 5889	0·063 7178	15·69420	0·997 9762	0·067 9427	0·068 1001	14·68427	0·997 6892	25
36	·063 6614	·063 7908	·67623	·997 9716	·068 0153	·068 1732	·66853	·997 6843	24
37	·063 7340	·063 8639	·65831	·997 9669	·068 0878	·068 2462	·65283	·997 6793	23
38	·063 8066	·063 9369	·64043	·997 9623	·068 1604	·068 3193	·63716	·997 6744	22
39	·063 8792	·064 0099	·62259	·997 9576	·068 2329	·068 3923	·62152	·997 6694	21
40	0·063 9517	0·064 0829	15·60478	0·997 9530	0·068 3055	0·068 4654	14·60592	0·997 6645	20
41	·064 0243	·064 1559	·58702	·997 9483	·068 3781	·068 5385	·59035	·997 6595	19
42	·064 0969	·064 2290	·56930	·997 9437	·068 4506	·068 6115	·57481	·997 6545	18
43	·064 1695	·064 3020	·55162	·997 9390	·068 5232	·068 6846	·55930	·997 6495	17
44	·064 2420	·064 3750	·53398	·997 9343	·068 5957	·068 7577	·54383	·997 6445	16
45	0·064 3146	0·064 4480	15·51638	0·997 9297	0·068 6683	0·068 8307	14·52839	0·997 6395	15
46	·064 3872	·064 5210	·49882	·997 9250	·068 7408	·068 9038	·51299	·997 6346	14
47	·064 4597	·064 5941	·48130	·997 9203	·068 8134	·068 9769	·49761	·997 6296	13
48	·064 5323	·064 6671	·46381	·997 9156	·068 8859	·069 0499	·48227	·997 6245	12
49	·064 6049	·064 7401	·44637	·997 9109	·068 9585	·069 1230	·46696	·997 6195	11
50	0·064 6774	0·064 8132	15·42897	0·997 9062	0·069 0310	0·069 1961	14·45169	0·997 6145	10
51	·064 7500	·064 8862	·41160	·997 9015	·069 1036	·069 2691	·43644	·997 6095	09
52	·064 8226	·064 9592	·39428	·997 8968	·069 1761	·069 3422	·42123	·997 6045	08
53	·064 8952	·065 0322	·37699	·997 8921	·069 2487	·069 4153	·40605	·997 5994	07
54	·064 9677	·065 1053	·35974	·997 8874	·069 3212	·069 4884	·39090	·997 5944	06
55	0·065 0403	0·065 1783	15·34253	0·997 8826	0·069 3937	0·069 5614	14·37578	0·997 5893	05
56	·065 1129	·065 2513	·32536	·997 8779	·069 4663	·069 6345	·36070	·997 5843	04
57	·065 1854	·065 3244	·30822	·997 8732	·069 5388	·069 7076	·34564	·997 5792	03
58	·065 2580	·065 3974	·29113	·997 8684	·069 6114	·069 7807	·33062	·997 5742	02
59	·065 3306	·065 4704	·27407	·997 8637	·069 6839	·069 8537	·31563	·997 5691	01
60	0·065 4031	0·065 5435	15·25705	0·997 8589	0·069 7565	0·069 9268	14·30067	0·997 5641	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	725–726	731–730	1702–1949	48–44	725–726	731–730	1496–1698	51–47	d

$5^h\ 45^m$ $5^h\ 44^m$

$0^h\ 16^m$ $0^h\ 17^m$

d	726–725	730–732	1493–1325	51–54	726–725	731–732	1323–1183	54–57	d
	sin	tan	cot	cos	sin	tan	cot	cos	
s									
00	0·069 7565	0·069 9268	14·30067	0·997 5641	0·074 1085	0·074 3128	13·45663	0·997 2502	60
01	·069 8290	·069 9999	·28574	·997 5590	·074 1810	·074 3860	·44340	·997 2448	59
02	·069 9016	·070 0730	·27084	·997 5539	·074 2535	·074 4591	·43019	·997 2394	58
03	·069 9741	·070 1460	·25597	·997 5488	·074 3261	·074 5322	·41702	·997 2340	57
04	·070 0467	·070 2191	·24113	·997 5437	·074 3986	·074 6053	·40387	·997 2286	56
05	0·070 1192	0·070 2922	14·22633	0·997 5386	0·074 4711	0·074 6785	13·39074	0·997 2232	55
06	·070 1917	·070 3653	·21155	·997 5335	·074 5436	·074 7516	·37764	·997 2178	54
07	·070 2643	·070 4384	·19681	·997 5284	·074 6161	·074 8247	·36457	·997 2123	53
08	·070 3368	·070 5115	·18209	·997 5233	·074 6887	·074 8979	·35152	·997 2069	52
09	·070 4094	·070 5845	·16741	·997 5182	·074 7612	·074 9710	·33849	·997 2015	51
10	0·070 4819	0·070 6576	14·15275	0·997 5131	0·074 8337	0·075 0441	13·32550	0·997 1960	50
11	·070 5544	·070 7307	·13813	·997 5079	·074 9062	·075 1172	·31252	·997 1906	49
12	·070 6270	·070 8038	·12354	·997 5028	·074 9787	·075 1904	·29957	·997 1851	48
13	·070 6995	·070 8769	·10897	·997 4977	·075 0512	·075 2635	·28665	·997 1797	47
14	·070 7721	·070 9500	·09444	·997 4925	·075 1238	·075 3366	·27375	·997 1742	46
15	0·070 8446	0·071 0231	14·07993	0·997 4874	0·075 1963	0·075 4098	13·26088	0·997 1688	45
16	·070 9171	·071 0961	·06546	·997 4822	·075 2688	·075 4829	·24803	·997 1633	44
17	·070 9897	·071 1692	·05101	·997 4770	·075 3413	·075 5561	·23521	·997 1578	43
18	·071 0622	·071 2423	·03660	·997 4719	·075 4138	·075 6292	·22241	·997 1523	42
19	·071 1348	·071 3154	·02221	·997 4667	·075 4863	·075 7023	·20963	·997 1468	41
20	0·071 2073	0·071 3885	14·00786	0·997 4615	0·075 5589	0·075 7755	13·19688	0·997 1413	40
21	·071 2798	·071 4616	13·99353	·997 4564	·075 6314	·075 8486	·18416	·997 1358	39
22	·071 3524	·071 5347	·97923	·997 4512	·075 7039	·075 9217	·17146	·997 1303	38
23	·071 4249	·071 6078	·96496	·997 4460	·075 7764	·075 9949	·15878	·997 1248	37
24	·071 4974	·071 6809	·95072	·997 4408	·075 8489	·076 0680	·14613	·997 1193	36
25	0·071 5700	0·071 7540	13·93651	0·997 4356	0·075 9214	0·076 1412	13·13350	0·997 1138	35
26	·071 6425	·071 8271	·92232	·997 4304	·075 9939	·076 2143	·12089	·997 1083	34
27	·071 7151	·071 9002	·90817	·997 4252	·076 0664	·076 2875	·10831	·997 1028	33
28	·071 7876	·071 9733	·89405	·997 4199	·076 1390	·076 3606	·09576	·997 0972	32
29	·071 8601	·072 0464	·87995	·997 4147	·076 2115	·076 4338	·08322	·997 0917	31
30	0·071 9327	0·072 1195	13·86588	0·997 4095	0·076 2840	0·076 5069	13·07072	0·997 0861	30
31	·072 0052	·072 1926	·85184	·997 4043	·076 3565	·076 5801	·05823	·997 0806	29
32	·072 0777	·072 2657	·83783	·997 3990	·076 4290	·076 6532	·04577	·997 0750	28
33	·072 1503	·072 3388	·82384	·997 3938	·076 5015	·076 7264	·03333	·997 0695	27
34	·072 2228	·072 4119	·80989	·997 3885	·076 5740	·076 7995	·02092	·997 0639	26
35	0·072 2953	0·072 4850	13·79596	0·997 3833	0·076 6465	0·076 8727	13·00853	0·997 0583	25
36	·072 3678	·072 5581	·78206	·997 3780	·076 7190	·076 9458	12·99616	·997 0528	24
37	·072 4404	·072 6312	·76819	·997 3727	·076 7915	·077 0190	·98382	·997 0472	23
38	·072 5129	·072 7043	·75434	·997 3675	·076 8640	·077 0921	·97150	·997 0416	22
39	·072 5854	·072 7774	·74053	·997 3622	·076 9365	·077 1653	·95920	·997 0360	21
40	0·072 6580	0·072 8505	13·72674	0·997 3569	0·077 0091	0·077 2384	12·94692	0·997 0304	20
41	·072 7305	·072 9236	·71298	·997 3516	·077 0816	·077 3116	·93467	·997 0248	19
42	·072 8030	·072 9967	·69924	·997 3463	·077 1541	·077 3847	·92244	·997 0192	18
43	·072 8756	·073 0698	·68554	·997 3410	·077 2266	·077 4579	·91024	·997 0136	17
44	·072 9481	·073 1430	·67186	·997 3357	·077 2991	·077 5311	·89806	·997 0080	16
45	0·073 0206	0·073 2161	13·65820	0·997 3304	0·077 3716	0·077 6042	12·88590	0·997 0023	15
46	·073 0931	·073 2892	·64458	·997 3251	·077 4441	·077 6774	·87376	·996 9967	14
47	·073 1657	·073 3623	·63098	·997 3198	·077 5166	·077 7505	·86165	·996 9911	13
48	·073 2382	·073 4354	·61741	·997 3145	·077 5891	·077 8237	·84956	·996 9854	12
49	·073 3107	·073 5085	·60386	·997 3091	·077 6616	·077 8969	·83749	·996 9798	11
50	0·073 3832	0·073 5816	13·59035	0·997 3038	0·077 7341	0·077 9700	12·82544	0·996 9741	10
51	·073 4558	·073 6548	·57686	·997 2985	·077 8066	·078 0432	·81342	·996 9685	09
52	·073 5283	·073 7279	·56339	·997 2931	·077 8791	·078 1164	·80142	·996 9628	08
53	·073 6008	·073 8010	·54995	·997 2878	·077 9516	·078 1895	·78944	·996 9571	07
54	·073 6734	·073 8741	·53654	·997 2824	·078 0241	·078 2627	·77748	·996 9515	06
55	0·073 7459	0·073 9472	13·52316	0·997 2771	0·078 0966	0·078 3359	12·76555	0·996 9458	05
56	·073 8184	·074 0203	·50980	·997 2717	·078 1691	·078 4090	·75363	·996 9401	04
57	·073 8909	·074 0935	·49647	·997 2663	·078 2416	·078 4822	·74174	·996 9344	03
58	·073 9634	·074 1666	·48316	·997 2610	·078 3141	·078 5554	·72988	·996 9287	02
59	·074 0360	·074 2397	·46988	·997 2556	·078 3866	·078 6285	·71803	·996 9230	01
60	0·074 1085	0·074 3128	13·45663	0·997 2502	0·078 4591	0·078 7017	12·70620	0·996 9173	00
									s
	cos	cot	tan	sin	cos	cot	tan	sin	
d	725–726	732–730	1325–1493	54–51	725–726	732–731	1183–1323	57–54	d

$5^h\ 43^m$ $5^h\ 42^m$

$0^{h}\ 18^{m}$ $0^{h}\ 19^{m}$

d	725–724	731–733	1180–1062	57–60	725–724	732–733	1059–958	60–64	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·078 4591	0·078 7017	12·70620	0·996 9173	0·082 8082	0·083 0936	12·03462	0·996 5655	60
01	·078 5316	·078 7749	·69440	·996 9116	·082 8807	·083 1668	·02403	·996 5595	59
02	·078 6041	·078 8481	·68262	·996 9059	·082 9532	·083 2400	·01345	·996 5534	58
03	·078 6766	·078 9212	·67086	·996 9002	·083 0256	·083 3133	12·00289	·996 5474	57
04	·078 7491	·078 9944	·65912	·996 8945	·083 0981	·083 3865	11·99235	·996 5414	56
05	0·078 8216	0·079 0676	12·64741	0·996 8887	0·083 1706	0·083 4597	11·98183	0·996 5353	55
06	·078 8941	·079 1408	·63571	·996 8830	·083 2430	·083 5330	·97132	·996 5293	54
07	·078 9666	·079 2139	·62404	·996 8773	·083 3155	·083 6062	·96084	·996 5232	53
08	·079 0391	·079 2871	·61239	·996 8715	·083 3880	·083 6794	·95037	·996 5172	52
09	·079 1116	·079 3603	·60076	·996 8658	·083 4604	·083 7526	·93992	·996 5111	51
10	0·079 1841	0·079 4335	12·58915	0·996 8600	0·083 5329	0·083 8259	11·92949	0·996 5050	50
11	·079 2565	·079 5067	·57756	·996 8543	·083 6054	·083 8991	·91908	·996 4989	49
12	·079 3290	·079 5798	·56600	·996 8485	·083 6778	·083 9723	·90868	·996 4929	48
13	·079 4015	·079 6530	·55445	·996 8427	·083 7503	·084 0456	·89831	·996 4868	47
14	·079 4740	·079 7262	·54293	·996 8369	·083 8228	·084 1188	·88795	·996 4807	46
15	0·079 5465	0·079 7994	12·53142	0·996 8312	0·083 8952	0·084 1921	11·87761	0·996 4746	45
16	·079 6190	·079 8726	·51994	·996 8254	·083 9677	·084 2653	·86728	·996 4685	44
17	·079 6915	·079 9458	·50848	·996 8196	·084 0402	·084 3385	·85698	·996 4624	43
18	·079 7640	·080 0189	·49704	·996 8138	·084 1126	·084 4118	·84669	·996 4563	42
19	·079 8365	·080 0921	·48562	·996 8080	·084 1851	·084 4850	·83642	·996 4501	41
20	0·079 9090	0·080 1653	12·47422	0·996 8022	0·084 2576	0·084 5583	11·82617	0·996 4440	40
21	·079 9815	·080 2385	·46284	·996 7964	·084 3300	·084 6315	·81593	·996 4379	39
22	·080 0539	·080 3117	·45149	·996 7905	·084 4025	·084 7047	·80571	·996 4317	38
23	·080 1264	·080 3849	·44015	·996 7847	·084 4750	·084 7780	·79552	·996 4256	37
24	·080 1989	·080 4581	·42883	·996 7789	·084 5474	·084 8512	·78533	·996 4195	36
25	0·080 2714	0·080 5313	12·41753	0·996 7730	0·084 6199	0·084 9245	11·77517	0 996 4133	35
26	·080 3439	·080 6045	·40626	·996 7672	·084 6923	·084 9977	·76502	·996 4071	34
27	·080 4164	·080 6777	·39500	·996 7614	·084 7648	·085 0710	·75489	·996 4010	33
28	·080 4889	·080 7509	·38377	·996 7555	·084 8373	·085 1442	·74478	·996 3948	32
29	·080 5614	·080 8241	·37255	·996 7497	·084 9097	·085 2175	·73468	·996 3886	31
30	0·080 6338	0·080 8973	12·36136	0·996 7438	0·084 9822	0·085 2907	11·72461	0·996 3825	30
31	·080 7063	·080 9705	·35018	·996 7379	·085 0546	·085 3640	·71454	·996 3763	29
32	·080 7788	·081 0437	·33903	·996 7321	·085 1271	·085 4372	·70450	·996 3701	28
33	·080 8513	·081 1169	·32789	·996 7262	·085 1996	·085 5105	·69447	·996 3639	27
34	·080 9238	·081 1901	·31678	·996 7203	·085 2720	·085 5837	·68446	·996 3577	26
35	0·080 9963	0·081 2633	12·30568	0·996 7144	0·085 3445	0·085 6570	11·67447	0·996 3515	25
36	·081 0687	·081 3365	·29461	·996 7085	·085 4169	·085 7302	·66450	·996 3453	24
37	·081 1412	·081 4097	·28355	·996 7026	·085 4894	·085 8035	·65454	·996 3391	23
38	·081 2137	·081 4829	·27252	·996 6967	·085 5618	·085 8768	·64459	·996 3329	22
39	·081 2862	·081 5561	·26150	·996 6908	·085 6343	·085 9500	·63467	·996 3266	21
40	0·081 3587	0·081 6293	12·25051	0·996 6849	0·085 7067	0·086 0233	11·62476	0·996 3204	20
41	·081 4312	·081 7025	·23953	·996 6790	·085 7792	·086 0965	·61487	·996 3142	19
42	·081 5036	·081 7757	·22857	·996 6730	·085 8517	·086 1698	·60499	·996 3079	18
43	·081 5761	·081 8489	·21763	·996 6671	·085 9241	·086 2431	·59514	·996 3017	17
44	·081 6486	·081 9221	·20672	·996 6612	·085 9966	·086 3163	·58529	·996 2954	16
45	0·081 7211	0·081 9953	12·19582	0·996 6552	0·086 0690	0·086 3896	11·57547	0·996 2892	15
46	·081 7936	·082 0685	·18494	·996 6493	·086 1415	·086 4629	·56566	·996 2829	14
47	·081 8660	·082 1418	·17408	·996 6433	·086 2139	·086 5361	·55587	·996 2766	13
48	·081 9385	·082 2150	·16324	·996 6374	·086 2864	·086 6094	·54609	·996 2704	12
49	·082 0110	·082 2882	·15241	·996 6314	·086 3588	·086 6827	·53633	·996 2641	11
50	0·082 0835	0·082 3614	12·14161	0·996 6255	0·086 4313	0·086 7559	11·52659	0·996 2578	10
51	·082 1559	·082 4346	·13083	·996 6195	·086 5037	·086 8292	·51686	·996 2515	09
52	·082 2284	·082 5078	·12006	·996 6135	·086 5762	·086 9025	·50715	·996 2452	08
53	·082 3009	·082 5810	·10932	·996 6075	·086 6486	·086 9757	·49746	·996 2389	07
54	·082 3734	·082 6543	·09859	·996 6015	·086 7211	·087 0490	·48778	·996 2326	06
55	0·082 4458	0·082 7275	12·08788	0·996 5955	0·086 7935	0·087 1223	11·47812	0·996 2263	05
56	·082 5183	·082 8007	·07719	·996 5895	·086 8660	·087 1956	·46847	·996 2200	04
57	·082 5908	·082 8739	·06652	·996 5835	·086 9384	·087 2688	·45884	·996 2137	03
58	·082 6633	·082 9471	·05587	·996 5775	·087 0109	·087 3421	·44923	·996 2074	02
59	·082 7357	·083 0204	·04524	·996 5715	·087 0833	·087 4154	·43963	·996 2010	01
60	0·082 8082	0·083 0936	12·03462	0·996 5655	0·087 1557	0·087 4887	11·43005	0·996 1947	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	724–725	733–731	1062–1180	60–57	724–725	733–732	958–1059	64–60	d

$5^{h}\ 41^{m}$ $5^{h}\ 40^{m}$

$0^h\ 20^m$ $0^h\ 21^m$

d	725–724	732–734	956–869	63–67	725–723	733–734	868–792	66–70	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·087 1557	0·087 4887	11·43005	0·996 1947	0·091 5016	0·091 8871	10·88292	0·995 8049	60
01	·087 2282	·087 5619	·42049	·996 1884	·091 5740	·091 9604	·87424	·995 7983	59
02	·087 3006	·087 6352	·41094	·996 1820	·091 6465	·092 0338	·86558	·995 7916	58
03	·087 3731	·087 7085	·40140	·996 1757	·091 7189	·092 1071	·85693	·995 7849	57
04	·087 4455	·087 7818	·39188	·996 1693	·091 7913	·092 1804	·84829	·995 7783	56
05	0·087 5180	0·087 8551	11·38238	0·996 1629	0·091 8637	0·092 2538	10·83966	0·995 7716	55
06	·087 5904	·087 9284	·37290	·996 1566	·091 9361	·092 3271	·83105	·995 7649	54
07	·087 6628	·088 0016	·36342	·996 1502	·092 0085	·092 4005	·82246	·995 7582	53
08	·087 7353	·088 0749	·35397	·996 1438	·092 0809	·092 4738	·81387	·995 7515	52
09	·087 8077	·088 1482	·34453	·996 1374	·092 1534	·092 5472	·80530	·995 7448	51
10	0·087 8802	0·088 2215	11·33511	0·996 1311	0·092 2258	0·092 6205	10·79675	0·995 7381	50
11	·087 9526	·088 2948	·32570	·996 1247	·092 2982	·092 6938	·78820	·995 7314	49
12	·088 0251	·088 3681	·31630	·996 1183	·092 3706	·092 7672	·77967	·995 7247	48
13	·088 0975	·088 4414	·30693	·996 1119	·092 4430	·092 8405	·77116	·995 7180	47
14	·088 1699	·088 5147	·29756	·996 1054	·092 5154	·092 9139	·76265	·995 7113	46
15	0·088 2424	0·088 5879	11·28822	0·996 0990	0·092 5878	0·092 9872	10·75416	0·995 7045	45
16	·088 3148	·088 6612	·27889	·996 0926	·092 6602	·093 0606	·74569	·995 6978	44
17	·088 3872	·088 7345	·26957	·996 0862	·092 7326	·093 1339	·73722	·995 6910	43
18	·088 4597	·088 8078	·26027	·996 0798	·092 8050	·093 2073	·72877	·995 6843	42
19	·088 5321	·088 8811	·25098	·996 0733	·092 8775	·093 2807	·72034	·995 6775	41
20	0·088 6046	0·088 9544	11·24171	0·996 0669	0·092 9499	0·093 3540	10·71191	0·995 6708	40
21	·088 6770	·089 0277	·23246	·996 0604	·093 0223	·093 4274	·70350	·995 6640	39
22	·088 7494	·089 1010	·22322	·996 0540	·093 0947	·093 5007	·69510	·995 6573	38
23	·088 8219	·089 1743	·21399	·996 0475	·093 1671	·093 5741	·68672	·995 6505	37
24	·088 8943	·089 2476	·20478	·996 0411	·093 2395	·093 6474	·67835	·995 6437	36
25	0·088 9667	0·089 3209	11·19559	0·996 0346	0·093 3119	0·093 7208	10·66999	0·995 6369	35
26	·089 0392	·089 3942	·18640	·996 0281	·093 3843	·093 7942	·66164	·995 6301	34
27	·089 1116	·089 4675	·17724	·996 0216	·093 4567	·093 8675	·65331	·995 6233	33
28	·089 1840	·089 5408	·16809	·996 0152	·093 5291	·093 9409	·64499	·995 6165	32
29	·089 2565	·089 6141	·15895	·996 0087	·093 6015	·094 0143	·63669	·995 6097	31
30	0·089 3289	0·089 6874	11·14983	0·996 0022	0·093 6739	0·094 0876	10·62839	0·995 6029	30
31	·089 4013	·089 7608	·14073	·995 9957	·093 7463	·094 1610	·62011	·995 5961	29
32	·089 4738	·089 8341	·13163	·995 9892	·093 8187	·094 2344	·61184	·995 5893	28
33	·089 5462	·089 9074	·12256	·995 9827	·093 8911	·094 3077	·60359	·995 5825	27
34	·089 6186	·089 9807	·11350	·995 9762	·093 9635	·094 3811	·59534	·995 5756	26
35	0·089 6910	0·090 0540	11·10445	0·995 9696	0·094 0359	0·094 4545	10·58711	0·995 5688	25
36	·089 7635	·090 1273	·09542	·995 9631	·094 1083	·094 5278	·57889	·995 5620	24
37	·089 8359	·090 2006	·08640	·995 9566	·094 1807	·094 6012	·57069	·995 5551	23
38	·089 9083	·090 2739	·07739	·995 9500	·094 2531	·094 6746	·56250	·995 5483	22
39	·089 9808	·090 3472	·06841	·995 9435	·094 3255	·094 7480	·55432	·995 5414	21
40	0·090 0532	0·090 4206	11·05943	0·995 9370	0·094 3979	0·094 8213	10·54615	0·995 5345	20
41	·090 1256	·090 4939	·05047	·995 9304	·094 4703	·094 8947	·53800	·995 5277	19
42	·090 1980	·090 5672	·04152	·995 9238	·094 5427	·094 9681	·52985	·995 5208	18
43	·090 2705	·090 6405	·03259	·995 9173	·094 6151	·095 0415	·52172	·995 5139	17
44	·090 3429	·090 7138	·02368	·995 9107	·094 6875	·095 1148	·51361	·995 5070	16
45	0·090 4153	0·090 7872	11·01477	0·995 9041	0·094 7599	0·095 1882	10·50550	0·995 5002	15
46	·090 4877	·090 8605	11·00588	·995 8976	·094 8323	·095 2616	·49741	·995 4933	14
47	·090 5602	·090 9338	10·99701	·995 8910	·094 9047	·095 3350	·48933	·995 4864	13
48	·090 6326	·091 0071	·98815	·995 8844	·094 9771	·095 4084	·48126	·995 4795	12
49	·090 7050	·091 0805	·97930	·995 8778	·095 0495	·095 4818	·47321	·995 4726	11
50	0·090 7774	0·091 1538	10·97047	0·995 8712	0·095 1219	0·095 5551	10·46516	0·995 4656	10
51	·090 8498	·091 2271	·96165	·995 8646	·095 1942	·095 6285	·45713	·995 4587	09
52	·090 9223	·091 3004	·95285	·995 8580	·095 2666	·095 7019	·44911	·995 4518	08
53	·090 9947	·091 3738	·94406	·995 8514	·095 3390	·095 7753	·44111	·995 4449	07
54	·091 0671	·091 4471	·93528	·995 8448	·095 4114	·095 8487	·43311	·995 4379	06
55	0·091 1395	0·091 5204	10·92652	0·995 8381	0·095 4838	0·095 9221	10·42513	0·995 4310	05
56	·091 2119	·091 5938	·91777	·995 8315	·095 5562	·095 9955	·41716	·995 4240	04
57	·091 2844	·091 6671	·90904	·995 8249	·095 6286	·096 0689	·40920	·995 4171	03
58	·091 3568	·091 7404	·90032	·995 8182	·095 7010	·096 1423	·40125	·995 4101	02
59	·091 4292	·091 8138	·89161	·995 8116	·095 7734	·096 2157	·39332	·995 4032	01
60	0·091 5016	0·091 8871	10·88292	0·995 8049	0·095 8458	0·096 2890	10·38540	0·995 3962	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	724–725	734–732	869–956	67–63	723–725	734–733	792–868	70–66	d

$5^h\ 39^m$ $5^h\ 38^m$

$0^h\ 22^m$ $0^h\ 23^m$

d	724–723	734–735	791–725	69–73	724–723	734–736	724–666	73–76	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·095 8458	0·096 2890	10·38540	0·995 3962	0·100 1881	0·100 6947	9·93101	0·994 9685	60
01	·095 9181	·096 3624	·37749	·995 3892	·100 2604	·100 7682	·92377	·994 9612	59
02	·095 9905	·096 4358	·36959	·995 3822	·100 3328	·100 8416	·91654	·994 9539	58
03	·096 0629	·096 5092	·36170	·995 3753	·100 4051	·100 9151	·90932	·994 9466	57
04	·096 1353	·096 5826	·35383	·995 3683	·100 4775	·100 9886	·90211	·994 9393	56
05	0·096 2077	0·096 6560	10·34596	0·995 3613	0·100 5498	0·101 0620	9·89491	0·994 9320	55
06	·096 2801	·096 7294	·33811	·995 3543	·100 6222	·101 1355	·88773	·994 9247	54
07	·096 3525	·096 8028	·33027	·995 3473	·100 6945	·101 2089	·88055	·994 9174	53
08	·096 4248	·096 8763	·32245	·995 3403	·100 7669	·101 2824	·87338	·994 9101	52
09	·096 4972	·096 9497	·31463	·995 3333	·100 8392	·101 3559	·86623	·994 9027	51
10	0·096 5696	0·097 0231	10·30683	0·995 3262	0·100 9116	0·101 4294	9·85908	0·994 8954	50
11	·096 6420	·097 0965	·29904	·995 3192	·100 9839	·101 5028	·85194	·994 8881	49
12	·096 7144	·097 1699	·29126	·995 3122	·101 0563	·101 5763	·84482	·994 8807	48
13	·096 7867	·097 2433	·28349	·995 3051	·101 1286	·101 6498	·83770	·994 8734	47
14	·096 8591	·097 3167	·27573	·995 2981	·101 2010	·101 7232	·83059	·994 8660	46
15	0·096 9315	0·097 3901	10·26798	0·995 2911	0·101 2733	0·101 7967	9·82350	0·994 8586	45
16	·097 0039	·097 4635	·26025	·995 2840	·101 3457	·101 8702	·81641	·994 8513	44
17	·097 0763	·097 5369	·25253	·995 2769	·101 4180	·101 9437	·80934	·994 8439	43
18	·097 1486	·097 6103	·24482	·995 2699	·101 4904	·102 0171	·80227	·994 8365	42
19	·097 2210	·097 6838	·23712	·995 2628	·101 5627	·102 0906	·79522	·994 8291	41
20	0·097 2934	0·097 7572	10·22943	0·995 2557	0·101 6351	0·102 1641	9·78817	0·994 8217	40
21	·097 3658	·097 8306	·22175	·995 2487	·101 7074	·102 2376	·78114	·994 8144	39
22	·097 4381	·097 9040	·21409	·995 2416	·101 7798	·102 3111	·77411	·994 8070	38
23	·097 5105	·097 9774	·20643	·995 2345	·101 8521	·102 3846	·76710	·994 7996	37
24	·097 5829	·098 0509	·19879	·995 2274	·101 9245	·102 4580	·76009	·994 7921	36
25	0·097 6553	0·098 1243	10·19116	0·995 2203	0·101 9968	0·102 5315	9·75310	0·994 7847	35
26	·097 7276	·098 1977	·18354	·995 2132	·102 0691	·102 6050	·74611	·994 7773	34
27	·097 8000	·098 2711	·17593	·995 2061	·102 1415	·102 6785	·73914	·994 7699	33
28	·097 8724	·098 3446	·16833	·995 1990	·102 2138	·102 7520	·73217	·994 7625	32
29	·097 9448	·098 4180	·16075	·995 1919	·102 2862	·102 8255	·72522	·994 7550	31
30	0·098 0171	0·098 4914	10·15317	0·995 1847	0·102 3585	0·102 8990	9·71827	0·994 7476	30
31	·098 0895	·098 5648	·14561	·995 1776	·102 4308	·102 9725	·71133	·994 7401	29
32	·098 1619	·098 6383	·13805	·995 1705	·102 5032	·103 0460	·70441	·994 7327	28
33	·098 2343	·098 7117	·13051	·995 1633	·102 5755	·103 1195	·69749	·994 7252	27
34	·098 3066	·098 7851	·12298	·995 1562	·102 6479	·103 1930	·69058	·994 7178	26
35	0·098 3790	0·098 8586	10·11546	0·995 1490	0·102 7202	0·103 2664	9·68369	0·994 7103	25
36	·098 4514	·098 9320	·10795	·995 1419	·102 7925	·103 3399	·67680	·994 7028	24
37	·098 5237	·099 0054	·10046	·995 1347	·102 8649	·103 4134	·66992	·994 6953	23
38	·098 5961	·099 0789	·09297	·995 1275	·102 9372	·103 4869	·66305	·994 6879	22
39	·098 6685	·099 1523	·08550	·995 1204	·103 0095	·103 5604	·65620	·994 6804	21
40	0·098 7408	0·099 2257	10·07803	0·995 1132	0·103 0819	0·103 6340	9·64935	0·994 6729	20
41	·098 8132	·099 2992	·07058	·995 1060	·103 1542	·103 7075	·64251	·994 6654	19
42	·098 8856	·099 3726	·06314	·995 0988	·103 2265	·103 7810	·63568	·994 6579	18
43	·098 9579	·099 4460	·05570	·995 0916	·103 2989	·103 8545	·62886	·994 6504	17
44	·099 0303	·099 5195	·04828	·995 0844	·103 3712	·103 9280	·62205	·994 6428	16
45	0·099 1027	0·099 5929	10·04087	0·995 0772	0·103 4435	0·104 0015	9·61525	0·994 6353	15
46	·099 1750	·099 6664	·03347	·995 0700	·103 5159	·104 0750	·60846	·994 6278	14
47	·099 2474	·099 7398	·02609	·995 0628	·103 5882	·104 1485	·60167	·994 6203	13
48	·099 3197	·099 8133	·01871	·995 0556	·103 6605	·104 2220	·59490	·994 6127	12
49	·099 3921	·099 8867	·01134	·995 0483	·103 7329	·104 2955	·58814	·994 6052	11
50	0·099 4645	0·099 9602	10·00399	0·995 0411	0·103 8052	0·104 3690	9·58139	0·994 5976	10
51	·099 5368	·100 0336	9·99664	·995 0339	·103 8775	·104 4426	·57464	·994 5901	09
52	·099 6092	·100 1071	·98931	·995 0266	·103 9499	·104 5161	·56791	·994 5825	08
53	·099 6816	·100 1805	·98198	·995 0194	·104 0222	·104 5896	·56118	·994 5750	07
54	·099 7539	·100 2540	·97467	·995 0121	·104 0945	·104 6631	·55447	·994 5674	06
55	0·099 8263	0·100 3274	9·96736	0·995 0049	0·104 1668	0·104 7366	9·54776	0·994 5598	05
56	·099 8986	·100 4009	·96007	·994 9976	·104 2392	·104 8101	·54106	·994 5523	04
57	·099 9710	·100 4743	·95279	·994 9904	·104 3115	·104 8837	·53437	·994 5447	03
58	·100 0433	·100 5478	·94552	·994 9831	·104 3838	·104 9572	·52769	·994 5371	02
59	·100 1157	·100 6212	·93826	·994 9758	·104 4561	·105 0307	·52102	·994 5295	01
60	0·100 1881	0·100 6947	9·93101	0·994 9685	0·104 5285	0·105 1042	9·51436	0·994 5219	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	723–724	735–734	725–791	73–69	723–724	736–734	666–724	76–73	d

$5^h\ 37^m$ $5^h\ 36^m$

	$0^{h}\ 24^{m}$				$0^{h}\ 25^{m}$				
d	724–722	735–736	665–614	76–80	723–722	736–737	613–568	79–83	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·104 5285	0·105 1042	9·51436	0·994 5219	0·108 8669	0·109 5178	9·13093	0·994 0563	60
01	·104 6008	·105 1778	·50771	·994 5143	·108 9392	·109 5914	·12480	·994 0484	59
02	·104 6731	·105 2513	·50107	·994 5067	·109 0115	·109 6650	·11868	·994 0405	58
03	·104 7454	·105 3248	·49444	·994 4991	·109 0837	·109 7386	·11256	·994 0326	57
04	·104 8178	·105 3983	·48781	·994 4914	·109 1560	·109 8122	·10646	·994 0246	56
05	0·104 8901	0·105 4719	9·48120	0·994 4838	0·109 2283	0·109 8858	9·10036	0·994 0167	55
06	·104 9624	·105 5454	·47460	·994 4762	·109 3006	·109 9594	·09427	·994 0087	54
07	·105 0347	·105 6189	·46800	·994 4686	·109 3729	·110 0330	·08818	·994 0008	53
08	·105 1070	·105 6925	·46141	·994 4609	·109 4452	·110 1066	·08211	·993 9928	52
09	·105 1794	·105 7660	·45483	·994 4533	·109 5175	·110 1802	·07604	·993 9849	51
10	0·105 2517	0·105 8395	9·44826	0·994 4456	0·109 5897	0·110 2538	9·06998	0·993 9769	50
11	·105 3240	·105 9131	·44170	·994 4380	·109 6620	·110 3274	·06393	·993 9689	49
12	·105 3963	·105 9866	·43515	·994 4303	·109 7343	·110 4010	·05789	·993 9610	48
13	·105 4686	·106 0602	·42861	·994 4226	·109 8066	·110 4746	·05185	·993 9530	47
14	·105 5409	·106 1337	·42208	·994 4150	·109 8789	·110 5482	·04582	·993 9450	46
15	0·105 6133	0·106 2072	9·41555	0·994 4073	0·109 9512	0·110 6219	9·03980	0·993 9370	45
16	·105 6856	·106 2808	·40904	·994 3996	·110 0234	·110 6955	·03379	·993 9290	44
17	·105 7579	·106 3543	·40253	·994 3919	·110 0957	·110 7691	·02779	·993 9210	43
18	·105 8302	·106 4279	·39603	·994 3842	·110 1680	·110 8427	·02179	·993 9130	42
19	·105 9025	·106 5014	·38955	·994 3765	·110 2403	·110 9163	·01581	·993 9050	41
20	0·105 9748	0·106 5750	9·38307	0·994 3688	0·110 3126	0·110 9899	9·00983	0·993 8969	40
21	·106 0471	·106 6485	·37660	·994 3611	·110 3848	·111 0636	9·00385	·993 8889	39
22	·106 1194	·106 7221	·37013	·994 3534	·110 4571	·111 1372	8·99789	·993 8809	38
23	·106 1918	·106 7956	·36368	·994 3457	·110 5294	·111 2108	·99193	·993 8729	37
24	·106 2641	·106 8692	·35724	·994 3379	·110 6017	·111 2844	·98598	·993 8648	36
25	0·106 3364	0·106 9427	9·35080	0·994 3302	0·110 6739	0·111 3580	8·98004	0·993 8568	35
26	·106 4087	·107 0163	·34437	·994 3225	·110 7462	·111 4317	·97411	·993 8487	34
27	·106 4810	·107 0898	·33795	·994 3147	·110 8185	·111 5053	·96818	·993 8407	33
28	·106 5533	·107 1634	·33155	·994 3070	·110 8908	·111 5789	·96227	·993 8326	32
29	·106 6256	·107 2369	·32514	·994 2992	·110 9630	·111 6525	·95636	·993 8245	31
30	0·106 6979	0·107 3105	9·31875	0·994 2915	0·111 0353	0·111 7262	8·95045	0·993 8165	30
31	·106 7702	·107 3841	·31237	·994 2837	·111 1076	·111 7998	·94456	·993 8084	29
32	·106 8425	·107 4576	·30599	·994 2760	·111 1799	·111 8734	·93867	·993 8003	28
33	·106 9148	·107 5312	·29963	·994 2682	·111 2521	·111 9471	·93279	·993 7922	27
34	·106 9871	·107 6048	·29327	·994 2604	·111 3244	·112 0207	·92692	·993 7841	26
35	0·107 0595	0·107 6783	9·28692	0·994 2526	0·111 3967	0·112 0943	8·92106	0·993 7760	25
36	·107 1318	·107 7519	·28058	·994 2448	·111 4689	·112 1680	·91520	·993 7679	24
37	·107 2041	·107 8255	·27425	·994 2370	·111 5412	·112 2416	·90935	·993 7598	23
38	·107 2764	·107 8990	·26792	·994 2292	·111 6135	·112 3152	·90351	·993 7517	22
39	·107 3487	·107 9726	·26161	·994 2214	·111 6857	·112 3889	·89768	·993 7436	21
40	0·107 4210	0·108 0462	9·25530	0·994 2136	0·111 7580	0·112 4625	8·89185	0·993 7355	20
41	·107 4933	·108 1197	·24901	·994 2058	·111 8303	·112 5362	·88603	·993 7273	19
42	·107 5656	·108 1933	·24272	·994 1980	·111 9025	·112 6098	·88022	·993 7192	18
43	·107 6379	·108 2669	·23644	·994 1902	·111 9748	·112 6835	·87442	·993 7110	17
44	·107 7102	·108 3405	·23016	·994 1823	·112 0471	·112 7571	·86862	·993 7029	16
45	0·107 7825	0·108 4140	9·22390	0·994 1745	0·112 1193	0·112 8308	8·86283	0·993 6948	15
46	·107 8548	·108 4876	·21764	·994 1667	·112 1916	·112 9044	·85705	·993 6866	14
47	·107 9271	·108 5612	·21140	·994 1588	·112 2639	·112 9781	·85128	·993 6784	13
48	·107 9994	·108 6348	·20516	·994 1510	·112 3361	·113 0517	·84551	·993 6703	12
49	·108 0717	·108 7083	·19893	·994 1431	·112 4084	·113 1254	·83975	·993 6621	11
50	0·108 1439	0·108 7819	9·19270	0·994 1352	0·112 4806	0·113 1990	8·83400	0·993 6539	10
51	·108 2162	·108 8555	·18649	·994 1274	·112 5529	·113 2727	·82826	·993 6457	09
52	·108 2885	·108 9291	·18028	·994 1195	·112 6252	·113 3463	·82252	·993 6375	08
53	·108 3608	·109 0027	·17409	·994 1116	·112 6974	·113 4200	·81679	·993 6294	07
54	·108 4331	·109 0763	·16790	·994 1037	·112 7697	·113 4936	·81107	·993 6212	06
55	0·108 5054	0·109 1499	9·16172	0·994 0959	0·112 8419	0·113 5673	8·80535	0·993 6130	05
56	·108 5777	·109 2234	·15554	·994 0880	·112 9142	·113 6410	·79964	·993 6047	04
57	·108 6500	·109 2970	·14938	·994 0801	·112 9864	·113 7146	·79394	·993 5965	03
58	·108 7223	·109 3706	·14322	·994 0722	·113 0587	·113 7883	·78825	·993 5883	02
59	·108 7946	·109 4442	·13707	·994 0643	·113 1310	·113 8619	·78257	·993 5801	01
60	0·108 8669	0·109 5178	9·13093	0·994 0563	0·113 2032	0·113 9356	8·77689	0·993 5719	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	722–724	736–735	614–665	80–76	722–723	737–736	568–613	83–79	d
	$5^{h}\ 35^{m}$				$5^{h}\ 34^{m}$				

$0^{h}\ 26^{m}$ $0^{h}\ 27^{m}$

d	723–722	736–738	567–526	82–86	723–721	737–739	526–490	85–89	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·113 2032	0·113 9356	8·77689	0·993 5719	0·117 5374	0·118 3578	8·44896	0·993 0685	60
01	·113 2755	·114 0093	·77122	·993 5636	·117 6096	·118 4315	·44370	·993 0599	59
02	·113 3477	·114 0829	·76555	·993 5554	·117 6818	·118 5053	·43844	·993 0514	58
03	·113 4200	·114 1566	·75990	·993 5471	·117 7540	·118 5790	·43319	·993 0428	57
04	·113 4922	·114 2303	·75425	·993 5389	·117 8263	·118 6528	·42795	·993 0342	56
05	0·113 5645	0·114 3040	8·74860	0·993 5306	0·117 8985	0·118 7265	8·42272	0·993 0257	55
06	·113 6367	·114 3776	·74297	·993 5224	·117 9707	·118 8003	·41749	·993 0171	54
07	·113 7090	·114 4513	·73734	·993 5141	·118 0429	·118 8740	·41227	·993 0085	53
08	·113 7812	·114 5250	·73172	·993 5058	·118 1151	·118 9478	·40705	·992 9999	52
09	·113 8535	·114 5987	·72611	·993 4976	·118 1873	·119 0215	·40184	·992 9913	51
10	0·113 9257	0·114 6723	8·72050	0·993 4893	0·118 2595	0·119 0953	8·39664	0·992 9827	50
11	·113 9980	·114 7460	·71490	·993 4810	·118 3318	·119 1690	·39144	·992 9741	49
12	·114 0702	·114 8197	·70931	·993 4727	·118 4040	·119 2428	·38625	·992 9655	48
13	·114 1425	·114 8934	·70372	·993 4644	·118 4762	·119 3165	·38107	·992 9569	47
14	·114 2147	·114 9671	·69814	·993 4561	·118 5484	·119 3903	·37589	·992 9483	46
15	0·114 2870	0·115 0407	8·69257	0·993 4478	0·118 6206	0·119 4641	8·37072	0·992 9397	45
16	·114 3592	·115 1144	·68701	·993 4395	·118 6928	·119 5378	·36555	·992 9310	44
17	·114 4315	·115 1881	·68145	·993 4311	·118 7650	·119 6116	·36039	·992 9224	43
18	·114 5037	·115 2618	·67590	·993 4228	·118 8372	·119 6853	·35524	·992 9138	42
19	·114 5759	·115 3355	·67036	·993 4145	·118 9094	·119 7591	·35010	·992 9051	41
20	0·114 6482	0·115 4092	8·66482	0·993 4062	0·118 9816	0·119 8329	8·34496	0·992 8965	40
21	·114 7204	·115 4829	·65929	·993 3978	·119 0538	·119 9066	·33982	·992 8878	39
22	·114 7927	·115 5566	·65377	·993 3895	·119 1260	·119 9804	·33469	·992 8791	38
23	·114 8649	·115 6303	·64826	·993 3811	·119 1982	·120 0542	·32957	·992 8705	37
24	·114 9372	·115 7039	·64275	·993 3728	·119 2704	·120 1279	·32446	·992 8618	36
25	0·115 0094	0·115 7776	8·63725	0·993 3644	0·119 3427	0·120 2017	8·31935	0·992 8531	35
26	·115 0816	·115 8513	·63175	·993 3560	·119 4149	·120 2755	·31425	·992 8444	34
27	·115 1539	·115 9250	·62626	·993 3477	·119 4871	·120 3493	·30915	·992 8358	33
28	·115 2261	·115 9987	·62078	·993 3393	·119 5593	·120 4230	·30406	·992 8271	32
29	·115 2983	·116 0724	·61531	·993 3309	·119 6315	·120 4968	·29897	·992 8184	31
30	0·115 3706	0·116 1461	8·60984	0·993 3225	0·119 7037	0·120 5706	8·29390	0·992 8097	30
31	·115 4428	·116 2198	·60438	·993 3141	·119 7759	·120 6444	·28882	·992 8010	29
32	·115 5151	·116 2936	·59893	·993 3057	·119 8481	·120 7182	·28376	·992 7922	28
33	·115 5873	·116 3673	·59348	·993 2973	·119 9202	·120 7919	·27870	·992 7835	27
34	·115 6595	·116 4410	·58804	·993 2889	·119 9924	·120 8657	·27364	·992 7748	26
35	0·115 7318	0·116 5147	8·58261	0·993 2805	0·120 0646	0·120 9395	8·26860	0·992 7661	25
36	·115 8040	·116 5884	·57718	·993 2721	·120 1368	·121 0133	·26355	·992 7573	24
37	·115 8762	·116 6621	·57176	·993 2637	·120 2090	·121 0871	·25852	·992 7486	23
38	·115 9485	·116 7358	·56635	·993 2552	·120 2812	·121 1609	·25349	·992 7399	22
39	·116 0207	·116 8095	·56095	·993 2468	·120 3534	·121 2347	·24847	·992 7311	21
40	0·116 0929	0·116 8832	8·55555	0·993 2384	0·120 4256	0·121 3085	8·24345	0·992 7224	20
41	·116 1651	·116 9570	·55015	·993 2299	·120 4978	·121 3822	·23844	·992 7136	19
42	·116 2374	·117 0307	·54477	·993 2215	·120 5700	·121 4560	·23343	·992 7048	18
43	·116 3096	·117 1044	·53939	·993 2130	·120 6422	·121 5298	·22843	·992 6961	17
44	·116 3818	·117 1781	·53402	·993 2045	·120 7144	·121 6036	·22344	·992 6873	16
45	0·116 4541	0·117 2518	8·52865	0·993 1961	0·120 7866	0·121 6774	8·21845	0·992 6785	15
46	·116 5263	·117 3256	·52329	·993 1876	·120 8588	·121 7512	·21347	·992 6697	14
47	·116 5985	·117 3993	·51794	·993 1791	·120 9309	·121 8250	·20849	·992 6609	13
48	·116 6707	·117 4730	·51259	·993 1706	·121 0031	·121 8988	·20352	·992 6521	12
49	·116 7430	·117 5467	·50726	·993 1622	·121 0753	·121 9726	·19856	·992 6433	11
50	0·116 8152	0·117 6205	8·50192	0·993 1537	0·121 1475	0·122 0464	8·19360	0·992 6345	10
51	·116 8874	·117 6942	·49660	·993 1452	·121 2197	·122 1202	·18865	·992 6257	09
52	·116 9596	·117 7679	·49128	·993 1367	·121 2919	·122 1941	·18370	·992 6169	08
53	·117 0319	·117 8416	·48596	·993 1282	·121 3641	·122 2679	·17876	·992 6081	07
54	·117 1041	·117 9154	·48066	·993 1196	·121 4363	·122 3417	·17383	·992 5992	06
55	0·117 1763	0·117 9891	8·47536	0·993 1111	0·121 5084	0·122 4155	8·16890	0·992 5904	05
56	·117 2485	·118 0628	·47007	·993 1026	·121 5806	·122 4893	·16398	·992 5816	04
57	·117 3207	·118 1366	·46478	·993 0941	·121 6528	·122 5631	·15906	·992 5727	03
58	·117 3930	·118 2103	·45950	·993 0855	·121 7250	·122 6369	·15415	·992 5639	02
59	·117 4652	·118 2841	·45422	·993 0770	·121 7972	·122 7107	·14925	·992 5550	01
60	0·117 5374	0·118 3578	8·44896	0·993 0685	0·121 8693	0·122 7846	8·14435	0·992 5462	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	722–723	738–736	526–567	86–82	721–723	739–737	490–526	89–85	d

$5^{h}\ 33^{m}$ $5^{h}\ 32^{m}$

$0^{h}\ 28^{m}$ $0^{h}\ 29^{m}$

d	722–721	738–739	490–457	88–92	722–721	739–740	456–427	91–95	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·121 8693	0·122 7846	8·14435	0·992 5462	0·126 1990	0·127 2161	7·86064	0·992 0049	60
01	·121 9415	·122 8584	·13945	·992 5373	·126 2711	·127 2900	·85608	·991 9958	59
02	·122 0137	·122 9322	·13457	·992 5284	·126 3432	·127 3639	·85152	·991 9866	58
03	·122 0859	·123 0060	·12968	·992 5195	·126 4154	·127 4378	·84697	·991 9774	57
04	·122 1581	·123 0798	·12481	·992 5107	·126 4875	·127 5117	·84242	·991 9682	56
05	0·122 2302	0·123 1537	8·11994	0·992 5018	0·126 5597	0·127 5856	7·83788	0·991 9590	55
06	·122 3024	·123 2275	·11507	·992 4929	·126 6318	·127 6595	·83334	·991 9498	54
07	·122 3746	·123 3013	·11021	·992 4840	·126 7039	·127 7334	·82881	·991 9406	53
08	·122 4468	·123 3752	·10536	·992 4751	·126 7761	·127 8073	·82428	·991 9314	52
09	·122 5189	·123 4490	·10051	·992 4662	·126 8482	·127 8812	·81976	·991 9221	51
10	0·122 5911	0·123 5228	8·09567	0·992 4573	0·126 9203	0·127 9551	7·81524	0·991 9129	50
11	·122 6633	·123 5966	·09083	·992 4483	·126 9925	·128 0290	·81073	·991 9037	49
12	·122 7355	·123 6705	·08600	·992 4394	·127 0646	·128 1030	·80622	·991 8944	48
13	·122 8076	·123 7443	·08118	·992 4305	·127 1367	·128 1769	·80172	·991 8852	47
14	·122 8798	·123 8181	·07636	·992 4216	·127 2089	·128 2508	·79722	·991 8760	46
15	0·122 9520	0·123 8920	8·07155	0·992 4126	0·127 2810	0·128 3247	7·79273	0·991 8667	45
16	·123 0241	·123 9658	·06674	·992 4037	·127 3531	·128 3986	·78825	·991 8574	44
17	·123 0963	·124 0397	·06194	·992 3947	·127 4253	·128 4725	·78376	·991 8482	43
18	·123 1685	·124 1135	·05714	·992 3858	·127 4974	·128 5465	·77929	·991 8389	42
19	·123 2406	·124 1873	·05235	·992 3768	·127 5695	·128 6204	·77482	·991 8296	41
20	0·123 3128	0·124 2612	8·04756	0·992 3679	0·127 6416	0·128 6943	7·77035	0·991 8204	40
21	·123 3850	·124 3350	·04279	·992 3589	·127 7138	·128 7682	·76589	·991 8111	39
22	·123 4571	·124 4089	·03801	·992 3499	·127 7859	·128 8422	·76143	·991 8018	38
23	·123 5293	·124 4827	·03324	·992 3409	·127 8580	·128 9161	·75698	·991 7925	37
24	·123 6015	·124 5566	·02848	·992 3319	·127 9302	·128 9900	·75254	·991 7832	36
25	0·123 6736	0·124 6304	8·02372	0·992 3229	0·128 0023	0·129 0640	7·74810	0·991 7739	35
26	·123 7458	·124 7043	·01897	·992 3140	·128 0744	·129 1379	·74366	·991 7646	34
27	·123 8180	·124 7781	·01422	·992 3049	·128 1465	·129 2118	·73923	·991 7552	33
28	·123 8901	·124 8520	·00948	·992 2959	·128 2186	·129 2858	·73480	·991 7459	32
29	·123 9623	·124 9259	·00475	·992 2869	·128 2908	·129 3597	·73038	·991 7366	31
30	0·124 0345	0·124 9997	8·00002	0·992 2779	0·128 3629	0·129 4337	7·72597	0·991 7273	30
31	·124 1066	·125 0736	7·99529	·992 2689	·128 4350	·129 5076	·72155	·991 7179	29
32	·124 1788	·125 1474	·99058	·992 2599	·128 5071	·129 5815	·71715	·991 7086	28
33	·124 2509	·125 2213	·98586	·992 2508	·128 5792	·129 6555	·71275	·991 6992	27
34	·124 3231	·125 2952	·98115	·992 2418	·128 6514	·129 7294	·70835	·991 6899	26
35	0·124 3952	0·125 3690	7·97645	0·992 2327	0·128 7235	0·129 8034	7·70396	0·991 6805	25
36	·124 4674	·125 4429	·97176	·992 2237	·128 7956	·129 8773	·69957	·991 6712	24
37	·124 5396	·125 5168	·96706	·992 2146	·128 8677	·129 9513	·69519	·991 6618	23
38	·124 6117	·125 5906	·96238	·992 2056	·128 9398	·130 0252	·69082	·991 6524	22
39	·124 6839	·125 6645	·95770	·992 1965	·129 0119	·130 0992	·68644	·991 6430	21
40	0·124 7560	0·125 7384	7·95302	0·992 1874	0·129 0841	0·130 1731	7·68208	0·991 6337	20
41	·124 8282	·125 8122	·94835	·992 1784	·129 1562	·130 2471	·67772	·991 6243	19
42	·124 9003	·125 8861	·94369	·992 1693	·129 2283	·130 3210	·67336	·991 6149	18
43	·124 9725	·125 9600	·93903	·992 1602	·129 3004	·130 3950	·66901	·991 6055	17
44	·125 0446	·126 0339	·93438	·992 1511	·129 3725	·130 4690	·66466	·991 5961	16
45	0·125 1168	0·126 1077	7·92973	0·992 1420	0·129 4446	0·130 5429	7·66032	0·991 5867	15
46	·125 1889	·126 1816	·92508	·992 1329	·129 5167	·130 6169	·65598	·991 5772	14
47	·125 2611	·126 2555	·92045	·992 1238	·129 5888	·130 6908	·65165	·991 5678	13
48	·125 3332	·126 3294	·91582	·992 1147	·129 6609	·130 7648	·64732	·991 5584	12
49	·125 4054	·126 4033	·91119	·992 1056	·129 7331	·130 8388	·64299	·991 5490	11
50	0·125 4775	0·126 4771	7·90657	0·992 0965	0·129 8052	0·130 9127	7·63868	0·991 5395	10
51	·125 5497	·126 5510	·90195	·992 0873	·129 8773	·130 9867	·63436	·991 5301	09
52	·125 6218	·126 6249	·89734	·992 0782	·129 9494	·131 0607	·63005	·991 5206	08
53	·125 6940	·126 6988	·89273	·992 0691	·130 0215	·131 1347	·62575	·991 5112	07
54	·125 7661	·126 7727	·88813	·992 0599	·130 0936	·131 2086	·62145	·991 5017	06
55	0·125 8383	0·126 8466	7·88354	0·992 0508	0·130 1657	0·131 2826	7·61716	0·991 4923	05
56	·125 9104	·126 9205	·87895	·992 0416	·130 2378	·131 3566	·61287	·991 4828	04
57	·125 9825	·126 9944	·87436	·992 0325	·130 3099	·131 4306	·60858	·991 4733	03
58	·126 0547	·127 0683	·86979	·992 0233	·130 3820	·131 5045	·60430	·991 4638	02
59	·126 1268	·127 1422	·86521	·992 0141	·130 4541	·131 5785	·60002	·991 4544	01
60	0·126 1990	0·127 2161	7·86064	9·992 0049	0·130 5262	0·131 6525	7·59575	0·991 4449	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	721–722	739–738	457–490	92–88	721–722	740–739	427–456	95–91	d

$5^{h}\ 31^{m}$ $5^{h}\ 30^{m}$

$0^{h}\ 30^{m}$ **$0^{h}\ 31^{m}$**

d	721–720	739–741	426–400	95–98	721–720	740–742	400–376	98–101	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·130 5262	0·131 6525	7·59575	0·991 4449	0·134 8509	0·136 0940	7·34786	0·990 8659	60
01	·130 5983	·131 7265	·59149	·991 4354	·134 9230	·136 1681	·34386	·990 8561	59
02	·130 6704	·131 8005	·58723	·991 4259	·134 9950	·136 2422	·33987	·990 8463	58
03	·130 7425	·131 8745	·58297	·991 4164	·135 0671	·136 3162	·33588	·990 8365	57
04	·130 8146	·131 9484	·57872	·991 4069	·135 1392	·136 3903	·33190	·990 8266	56
05	0·130 8867	0·132 0224	7·57447	0·991 3973	0·135 2112	0·136 4644	7·32792	0·990 8168	55
06	·130 9588	·132 0964	·57023	·991 3878	·135 2833	·136 5385	·32394	·990 8070	54
07	·131 0309	·132 1704	·56599	·991 3783	·135 3553	·136 6125	·31997	·990 7971	53
08	·131 1030	·132 2444	·56176	·991 3688	·135 4274	·136 6866	·31600	·990 7873	52
09	·131 1751	·132 3184	·55753	·991 3592	·135 4994	·136 7607	·31204	·990 7774	51
10	0·131 2472	0·132 3924	7·55330	0·991 3497	0·135 5715	0·136 8348	7·30808	0·990 7676	50
11	·131 3192	·132 4664	·54908	·991 3401	·135 6435	·136 9089	·30413	·990 7577	49
12	·131 3913	·132 5404	·54487	·991 3306	·135 7156	·136 9830	·30018	·990 7478	48
13	·131 4634	·132 6144	·54066	·991 3210	·135 7876	·137 0570	·29623	·990 7380	47
14	·131 5355	·132 6884	·53645	·991 3115	·135 8597	·137 1311	·29229	·990 7281	46
15	0·131 6076	0·132 7624	7·53225	0·991 3019	0·135 9317	0·137 2052	7·28835	0·990 7182	45
16	·131 6797	·132 8364	·52806	·991 2923	·136 0038	·137 2793	·28442	·990 7083	44
17	·131 7518	·132 9104	·52387	·991 2827	·136 0758	·137 3534	·28049	·990 6984	43
18	·131 8239	·132 9844	·51968	·991 2732	·136 1479	·137 4275	·27656	·990 6885	42
19	·131 8960	·133 0584	·51550	·991 2636	·136 2199	·137 5016	·27264	·990 6786	41
20	0·131 9681	0·133 1324	7·51132	0·991 2540	0·136 2919	0·137 5757	7·26873	0·990 6687	40
21	·132 0401	·133 2064	·50714	·991 2444	·136 3640	·137 6498	·26481	·990 6588	39
22	·132 1122	·133 2805	·50298	·991 2348	·136 4360	·137 7239	·26090	·990 6489	38
23	·132 1843	·133 3545	·49881	·991 2252	·136 5081	·137 7980	·25700	·990 6390	37
24	·132 2564	·133 4285	·49465	·991 2155	·136 5801	·137 8721	·25310	·990 6290	36
25	0·132 3285	0·133 5025	7·49050	0·991 2059	0·136 6522	0·137 9462	7·24920	0·990 6191	35
26	·132 4006	·133 5765	·48635	·991 1963	·136 7242	·138 0203	·24531	·990 6092	34
27	·132 4726	·133 6505	·48220	·991 1867	·136 7962	·138 0944	·24142	·990 5992	33
28	·132 5447	·133 7246	·47806	·991 1770	·136 8683	·138 1685	·23754	·990 5893	32
29	·132 6168	·133 7986	·47392	·991 1674	·136 9403	·138 2426	·23366	·990 5793	31
30	0·132 6889	0·133 8726	7·46979	0·991 1577	0·137 0123	0·138 3168	7·22978	0·990 5693	30
31	·132 7610	·133 9466	·46566	·991 1481	·137 0844	·138 3909	·22591	·990 5594	29
32	·132 8330	·134 0207	·46154	·991 1384	·137 1564	·138 4650	·22204	·990 5494	28
33	·132 9051	·134 0947	·45742	·991 1288	·137 2284	·138 5391	·21818	·990 5394	27
34	·132 9772	·134 1687	·45330	·991 1191	·137 3005	·138 6132	·21432	·990 5294	26
35	0·133 0493	0·134 2428	7·44919	0·991 1094	0·137 3725	0·138 6873	7·21046	0·990 5195	25
36	·133 1213	·134 3168	·44509	·991 0997	·137 4445	·138 7615	·20661	·990 5095	24
37	·133 1934	·134 3908	·44098	·991 0901	·137 5166	·138 8356	·20276	·990 4995	23
38	·133 2655	·134 4649	·43689	·991 0804	·137 5886	·138 9097	·19892	·990 4895	22
39	·133 3376	·134 5389	·43279	·991 0707	·137 6606	·138 9838	·19508	·990 4795	21
40	0·133 4096	0·134 6129	7·42871	0·991 0610	0·137 7327	0·139 0580	7·19125	0·990 4694	20
41	·133 4817	·134 6870	·42462	·991 0513	·137 8047	·139 1321	·18741	·990 4594	19
42	·133 5538	·134 7610	·42054	·991 0416	·137 8767	·139 2062	·18359	·990 4494	18
43	·133 6258	·134 8351	·41647	·991 0319	·137 9488	·139 2804	·17976	·990 4394	17
44	·133 6979	·134 9091	·41240	·991 0221	·138 0208	·139 3545	·17594	·990 4293	16
45	0·133 7700	0·134 9832	7·40833	0·991 0124	0·138 0928	0·139 4286	7·17213	0·990 4193	15
46	·133 8421	·135 0572	·40427	·991 0027	·138 1648	·139 5028	·16832	·990 4092	14
47	·133 9141	·135 1313	·40021	·990 9929	·138 2369	·139 5769	·16451	·990 3992	13
48	·133 9862	·135 2053	·39616	·990 9832	·138 3089	·139 6510	·16071	·990 3891	12
49	·134 0583	·135 2794	·39211	·990 9735	·138 3809	·139 7252	·15691	·990 3791	11
50	0·134 1303	0·135 3534	7·38807	0·990 9637	0·138 4529	0·139 7993	7·15311	0·990 3690	10
51	·134 2024	·135 4275	·38403	·990 9539	·138 5249	·139 8735	·14932	·990 3589	09
52	·134 2744	·135 5015	·37999	·990 9442	·138 5970	·139 9476	·14553	·990 3489	08
53	·134 3465	·135 5756	·37596	·990 9344	·138 6690	·140 0218	·14175	·990 3388	07
54	·134 4186	·135 6496	·37193	·990 9246	·138 7410	·140 0959	·13797	·990 3287	06
55	0·134 4906	0·135 7237	7·36791	0·990 9149	0·138 8130	0·140 1701	7·13419	0·990 3186	05
56	·134 5627	·135 7978	·36389	·990 9051	·138 8850	·140 2442	·13042	·990 3085	04
57	·134 6348	·135 8718	·35988	·990 8953	·138 9571	·140 3184	·12665	·990 2984	03
58	·134 7068	·135 9459	·35587	·990 8855	·139 0291	·140 3925	·12289	·990 2883	02
59	·134 7789	·136 0200	·35186	·990 8757	·139 1011	·140 4667	·11913	·990 2782	01
60	0·134 8509	0·136 0940	7·34786	0·990 8659	0·139 1731	0·140 5408	7·11537	0·990 2681	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	720–721	741–739	400–426	98–95	720–721	742–740	376–400	101–98	d

$5^{h}\ 29^{m}$ **$5^{h}\ 28^{m}$**

$0^h\ 32^m$ $0^h\ 33^m$

d	721–719	741–743	375–353	101–105	720–719	742–744	353–333	104–108	d
	sin	tan	cot	cos	sin	tan	cot	cos	
s									
00	0·139 1731	0·140 5408	7·11537	0·990 2681	0·143 4926	0·144 9931	6·89688	0·989 6514	60
01	·139 2451	·140 6150	·11162	·990 2579	·143 5646	·145 0674	·89335	·989 6409	59
02	·139 3171	·140 6892	·10787	·990 2478	·143 6366	·145 1416	·88982	·989 6305	58
03	·139 3891	·140 7633	·10412	·990 2377	·143 7085	·145 2159	·88630	·989 6201	57
04	·139 4612	·140 8375	·10038	·990 2275	·143 7805	·145 2901	·88278	·989 6096	56
05	0·139 5332	0·140 9116	7·09665	0·990 2174	0·143 8525	0·145 3644	6·87926	0·989 5991	55
06	·139 6052	·140 9858	·09291	·990 2072	·143 9244	·145 4386	·87575	·989 5887	54
07	·139 6772	·141 0600	·08918	·990 1971	·143 9964	·145 5129	·87224	·989 5782	53
08	·139 7492	·141 1342	·08546	·990 1869	·144 0684	·145 5872	·86874	·989 5677	52
09	·139 8212	·141 2083	·08174	·990 1768	·144 1403	·145 6614	·86524	·989 5573	51
10	0·139 8932	0·141 2825	7·07802	0·990 1666	0·144 2123	0·145 7357	6·86174	0·989 5468	50
11	·139 9652	·141 3567	·07430	·990 1564	·144 2842	·145 8100	·85824	·989 5363	49
12	·140 0372	·141 4308	·07059	·990 1462	·144 3562	·145 8842	·85475	·989 5258	48
13	·140 1092	·141 5050	·06689	·990 1361	·144 4282	·145 9585	·85126	·989 5153	47
14	·140 1812	·141 5792	·06318	·990 1259	·144 5001	·146 0328	·84778	·989 5048	46
15	0·140 2532	0·141 6534	7·05949	0·990 1157	0·144 5721	0·146 1070	6·84430	0·989 4943	45
16	·140 3252	·141 7276	·05579	·990 1055	·144 6440	·146 1813	·84082	·989 4838	44
17	·140 3972	·141 8017	·05210	·990 0953	·144 7160	·146 2556	·83735	·989 4732	43
18	·140 4692	·141 8759	·04841	·990 0850	·144 7879	·146 3299	·83387	·989 4627	42
19	·140 5412	·141 9501	·04473	·990 0748	·144 8599	·146 4041	·83041	·989 4522	41
20	0·140 6132	0·142 0243	7·04105	0·990 0646	0·144 9319	0·146 4784	6·82694	0·989 4416	40
21	·140 6852	·142 0985	·03737	·990 0544	·145 0038	·146 5527	·82348	·989 4311	39
22	·140 7572	·142 1727	·03370	·990 0441	·145 0758	·146 6270	·82003	·989 4205	38
23	·140 8292	·142 2469	·03003	·990 0339	·145 1477	·146 7013	·81657	·989 4100	37
24	·140 9012	·142 3211	·02637	·990 0237	·145 2197	·146 7756	·81312	·989 3994	36
25	0·140 9732	0·142 3953	7·02271	0·990 0134	0·145 2916	0·146 8499	6·80968	0·989 3889	35
26	·141 0452	·142 4695	·01905	·990 0032	·145 3636	·146 9242	·80623	·989 3783	34
27	·141 1172	·142 5437	·01539	·989 9929	·145 4355	·146 9984	·80279	·989 3677	33
28	·141 1892	·142 6179	·01174	·989 9826	·145 5075	·147 0727	·79936	·989 3572	32
29	·141 2612	·142 6921	·00810	·989 9724	·145 5794	·147 1470	·79592	·989 3466	31
30	0·141 3332	0·142 7663	7·00446	0·989 9621	0·145 6514	0·147 2213	6·79249	0·989 3360	30
31	·141 4052	·142 8405	7·00082	·989 9518	·145 7233	·147 2956	·78907	·989 3254	29
32	·141 4772	·142 9147	6·99718	·989 9415	·145 7953	·147 3699	·78564	·989 3148	28
33	·141 5492	·142 9889	·99355	·989 9312	·145 8672	·147 4442	·78223	·989 3042	27
34	·141 6212	·143 0631	·98992	·989 9209	·145 9391	·147 5185	·77881	·989 2936	26
35	0·141 6931	0·143 1373	6·98630	0·989 9106	0·146 0111	0·147 5928	6·77540	0·989 2830	25
36	·141 7651	·143 2115	·98268	·989 9003	·146 0830	·147 6672	·77199	·989 2723	24
37	·141 8371	·143 2857	·97906	·989 8900	·146 1550	·147 7415	·76858	·989 2617	23
38	·141 9091	·143 3600	·97545	·989 8797	·146 2269	·147 8158	·76518	·989 2511	22
39	·141 9811	·143 4342	·97184	·989 8694	·146 2989	·147 8901	·76178	·989 2404	21
40	0·142 0531	0·143 5084	6·96823	0·989 8590	0·146 3708	0·147 9644	6·75838	0·989 2298	20
41	·142 1251	·143 5826	·96463	·989 8487	·146 4427	·148 0387	·75499	·989 2192	19
42	·142 1970	·143 6568	·96103	·989 8384	·146 5147	·148 1130	·75160	·989 2085	18
43	·142 2690	·143 7311	·95744	·989 8280	·146 5866	·148 1873	·74821	·989 1978	17
44	·142 3410	·143 8053	·95385	·989 8177	·146 6585	·148 2617	·74483	·989 1872	16
45	0·142 4130	0·143 8795	6·95026	0·989 8073	0·146 7305	0·148 3360	6·74145	0·989 1765	15
46	·142 4850	·143 9537	·94668	·989 7970	·146 8024	·148 4103	·73808	·989 1658	14
47	·142 5570	·144 0280	·94310	·989 7866	·146 8743	·148 4846	·73470	·989 1552	13
48	·142 6289	·144 1022	·93952	·989 7762	·146 9463	·148 5590	·73133	·989 1445	12
49	·142 7009	·144 1764	·93595	·989 7659	·147 0182	·148 6333	·72797	·989 1338	11
50	0·142 7729	0·144 2507	6·93238	0·989 7555	0·147 0901	0·148 7076	6·72461	0·989 1231	10
51	·142 8449	·144 3249	·92881	·989 7451	·147 1621	·148 7819	·72125	·989 1124	09
52	·142 9168	·144 3991	·92525	·989 7347	·147 2340	·148 8563	·71789	·989 1017	08
53	·142 9888	·144 4734	·92169	·989 7243	·147 3059	·148 9306	·71454	·989 0910	07
54	·143 0608	·144 5476	·91814	·989 7139	·147 3779	·149 0050	·71119	·989 0803	06
55	0·143 1328	0·144 6219	6·91458	0·989 7035	0·147 4498	0·149 0793	6·70784	0·989 0695	05
56	·143 2047	·144 6961	·91104	·989 6931	·147 5217	·149 1536	·70450	·989 0588	04
57	·143 2767	·144 7704	·90749	·989 6827	·147 5936	·149 2280	·70116	·989 0481	03
58	·143 3487	·144 8446	·90395	·989 6722	·147 6656	·149 3023	·69782	·989 0374	02
59	·143 4207	·144 9188	·90041	·989 6618	·147 7375	·149 3767	·69449	·989 0266	01
60	0·143 4926	0·144 9931	6·89688	0·989 6514	0·147 8094	0·149 4510	6·69116	0·989 0159	00
									s
	cos	cot	tan	sin	cos	cot	tan	sin	
d	719–721	743–741	353–375	105–101	719–720	744–742	333–353	108–104	d

$5^h\ 27^m$ $5^h\ 26^m$

	$0^{h}\ 34^{m}$				$0^{h}\ 35^{m}$				
d	720–718	743–745	333–315	107–111	719–718	744–746	314–297	110–114	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·147 8094	0·149 4510	6·69116	0·989 0159	0·152 1234	0·153 9147	6·49710	0·988 3615	60
01	·147 8813	·149 5253	·68783	·989 0051	·152 1953	·153 9892	·49396	·988 3504	59
02	·147 9533	·149 5997	·68451	·988 9944	·152 2671	·154 0636	·49083	·988 3394	58
03	·148 0252	·149 6740	·68118	·988 9836	·152 3390	·154 1381	·48769	·988 3283	57
04	·148 0971	·149 7484	·67787	·988 9728	·152 4109	·154 2125	·48456	·988 3172	56
05	0·148 1690	0·149 8228	6·67455	0·988 9621	0·152 4828	0·154 2870	6·48143	0·988 3061	55
06	·148 2409	·149 8971	·67124	·988 9513	·152 5546	·154 3614	·47830	·988 2950	54
07	·148 3129	·149 9715	·66794	·988 9405	·152 6265	·154 4359	·47518	·988 2839	53
08	·148 3848	·150 0458	·66463	·988 9297	·152 6984	·154 5103	·47206	·988 2728	52
09	·148 4567	·150 1202	·66133	·988 9189	·152 7702	·154 5848	·46894	·988 2617	51
10	0·148 5286	0·150 1945	6·65803	0·988 9081	0·152 8421	0·154 6593	6·46583	0·988 2506	50
11	·148 6005	·150 2689	·65474	·988 8973	·152 9140	·154 7337	·46272	·988 2395	49
12	·148 6724	·150 3433	·65144	·988 8865	·152 9858	·154 8082	·45961	·988 2284	48
13	·148 7443	·150 4176	·64816	·988 8757	·153 0577	·154 8826	·45650	·988 2173	47
14	·148 8163	·150 4920	·64487	·988 8649	·153 1296	·154 9571	·45340	·988 2061	46
15	0·148 8882	0·150 5664	6·64159	0·988 8540	0·153 2014	0·155 0316	6·45030	0·988 1950	45
16	·148 9601	·150 6408	·63831	·988 8432	·153 2733	·155 1061	·44720	·988 1838	44
17	·149 0320	·150 7151	·63503	·988 8324	·153 3452	·155 1805	·44411	·988 1727	43
18	·149 1039	·150 7895	·63176	·988 8215	·153 4170	·155 2550	·44102	·988 1615	42
19	·149 1758	·150 8639	·62849	·988 8107	·153 4889	·155 3295	·43793	·988 1504	41
20	0·149 2477	0·150 9383	6·62523	0·988 7998	0·153 5607	0·155 4040	6·43484	0·988 1392	40
21	·149 3196	·151 0126	·62196	·988 7890	·153 6326	·155 4784	·43176	·988 1280	39
22	·149 3915	·151 0870	·61870	·988 7781	·153 7045	·155 5529	·42868	·988 1169	38
23	·149 4634	·151 1614	·61545	·988 7673	·153 7763	·155 6274	·42560	·988 1057	37
24	·149 5353	·151 2358	·61219	·988 7564	·153 8482	·155 7019	·42253	·988 0945	36
25	0·149 6072	0·151 3102	6·60894	0·988 7455	0·153 9200	0·155 7764	6·41946	0·988 0833	35
26	·149 6792	·151 3846	·60569	·988 7346	·153 9919	·155 8509	·41639	·988 0721	34
27	·149 7511	·151 4589	·60245	·988 7237	·154 0637	·155 9253	·41333	·988 0609	33
28	·149 8230	·151 5333	·59921	·988 7128	·154 1356	·155 9998	·41026	·988 0497	32
29	·149 8949	·151 6077	·59597	·988 7019	·154 2074	·156 0743	·40720	·988 0385	31
30	0·149 9668	0·151 6821	6·59273	0·988 6910	0·154 2793	0·156 1488	6·40415	0·988 0273	30
31	·150 0387	·151 7565	·58950	·988 6801	·154 3511	·156 2233	·40109	·988 0161	29
32	·150 1106	·151 8309	·58627	·988 6692	·154 4230	·156 2978	·39804	·988 0048	28
33	·150 1825	·151 9053	·58305	·988 6583	·154 4948	·156 3723	·39499	·987 9936	27
34	·150 2543	·151 9797	·57983	·988 6474	·154 5667	·156 4468	·39195	·987 9824	26
35	0·150 3262	0·152 0541	6·57661	0·988 6364	0·154 6385	0·156 5213	6·38891	0·987 9711	25
36	·150 3981	·152 1285	·57339	·988 6255	·154 7104	·156 5958	·38587	·987 9599	24
37	·150 4700	·152 2029	·57018	·988 6146	·154 7822	·156 6703	·38283	·987 9486	23
38	·150 5419	·152 2773	·56697	·988 6036	·154 8541	·156 7448	·37980	·987 9374	22
39	·150 6138	·152 3517	·56376	·988 5927	·154 9259	·156 8193	·37676	·987 9261	21
40	0·150 6857	0·152 4262	6·56055	0·988 5817	0·154 9978	0·156 8939	6·37374	0·987 9148	20
41	·150 7576	·152 5006	·55735	·988 5708	·155 0696	·156 9684	·37071	·987 9035	19
42	·150 8295	·152 5750	·55415	·988 5598	·155 1415	·157 0429	·36769	·987 8923	18
43	·150 9014	·152 6494	·55096	·988 5488	·155 2133	·157 1174	·36467	·987 8810	17
44	·150 9733	·152 7238	·54777	·988 5378	·155 2851	·157 1919	·36165	·987 8697	16
45	0·151 0452	0·152 7982	6·54458	0·988 5269	0·155 3570	0·157 2664	6·35864	0·987 8584	15
46	·151 1170	·152 8727	·54139	·988 5159	·155 4288	·157 3410	·35562	·987 8471	14
47	·151 1889	·152 9471	·53821	·988 5049	·155 5006	·157 4155	·35262	·987 8358	13
48	·151 2608	·153 0215	·53503	·988 4939	·155 5725	·157 4900	·34961	·987 8245	12
49	·151 3327	·153 0959	·53185	·988 4829	·155 6443	·157 5645	·34661	·987 8132	11
50	0·151 4046	0·153 1704	6·52868	0·988 4719	0·155 7162	0·157 6391	6·34361	0·987 8018	10
51	·151 4765	·153 2448	·52551	·988 4609	·155 7880	·157 7136	·34061	·987 7905	09
52	·151 5484	·153 3192	·52234	·988 4498	·155 8598	·157 7881	·33761	·987 7792	08
53	·151 6202	·153 3936	·51917	·988 4388	·155 9317	·157 8627	·33462	·987 7678	07
54	·151 6921	·153 4681	·51601	·988 4278	·156 0035	·157 9372	·33163	·987 7565	06
55	0·151 7640	0·153 5425	6·51285	0·988 4168	0·156 0753	0·158 0117	6·32864	0·987 7452	05
56	·151 8359	·153 6170	·50970	·988 4057	·156 1472	·158 0863	·32566	·987 7338	04
57	·151 9078	·153 6914	·50655	·988 3947	·156 2190	·158 1608	·32268	·987 7224	03
58	·151 9796	·153 7658	·50340	·988 3836	·156 2908	·158 2354	·31970	·987 7111	02
59	·152 0515	·153 8403	·50025	·988 3726	·156 3626	·158 3099	·31672	·987 6997	01
60	0·152 1234	0·153 9147	6·49710	0·988 3615	0·156 4345	0·158 3844	6·31375	0·987 6883	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	718–720	745–743	315–333	111–107	718–719	746–744	297–314	114–110	d
	$5^{h}\ 25^{m}$				$5^{h}\ 24^{m}$				

$0^{\mathrm{h}}\ 36^{\mathrm{m}}$ $0^{\mathrm{h}}\ 37^{\mathrm{m}}$

d	719–717	745–747	297–281	113–117	718–717	746–748	281–267	117–120	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·156 4345	0·158 3844	6·31375	0·987 6883	0·160 7426	0·162 8603	6·14023	0·986 9964	60
01	·156 5063	·158 4590	·31078	·987 6770	·160 8143	·162 9350	·13742	·986 9847	59
02	·156 5781	·158 5335	·30781	·987 6656	·160 8861	·163 0096	·13461	·986 9730	58
03	·156 6499	·158 6081	·30485	·987 6542	·160 9579	·163 0843	·13180	·986 9613	57
04	·156 7218	·158 6826	·30189	·987 6428	·161 0297	·163 1590	·12899	·986 9496	56
05	0·156 7936	0·158 7572	6·29893	0·987 6314	0·161 1014	0·163 2336	6·12619	0·986 9379	55
06	·156 8654	·158 8317	·29597	·987 6200	·161 1732	·163 3083	·12339	·986 9261	54
07	·156 9372	·158 9063	·29302	·987 6086	·161 2450	·163 3829	·12059	·986 9144	53
08	·157 0091	·158 9809	·29007	·987 5972	·161 3167	·163 4576	·11779	·986 9027	52
09	·157 0809	·159 0554	·28712	·987 5857	·161 3885	·163 5323	·11500	·986 8909	51
10	0·157 1527	0·159 1300	6·28417	0·987 5743	0·161 4603	0·163 6069	6·11221	0·986 8792	50
11	·157 2245	·159 2046	·28123	·987 5629	·161 5321	·163 6816	·10942	·986 8675	49
12	·157 2963	·159 2791	·27829	·987 5514	·161 6038	·163 7563	·10664	·986 8557	48
13	·157 3681	·159 3537	·27535	·987 5400	·161 6756	·163 8310	·10385	·986 8440	47
14	·157 4400	·159 4283	·27241	·987 5286	·161 7474	·163 9056	·10107	·986 8322	46
15	0·157 5118	0·159 5028	6·26948	0·987 5171	0·161 8191	0·163 9803	6·09829	0·986 8204	45
16	·157 5836	·159 5774	·26655	·987 5057	·161 8909	·164 0550	·09552	·986 8087	44
17	·157 6554	·159 6520	·26362	·987 4942	·161 9626	·164 1297	·09274	·986 7969	43
18	·157 7272	·159 7266	·26070	·987 4827	·162 0344	·164 2043	·08997	·986 7851	42
19	·157 7990	·159 8011	·25778	·987 4712	·162 1062	·164 2790	·08720	·986 7733	41
20	0·157 8708	0·159 8757	6·25486	0·987 4598	0·162 1779	0·164 3537	6·08444	0·986 7615	40
21	·157 9426	·159 9503	·25194	·987 4483	·162 2497	·164 4284	·08167	·986 7497	39
22	·158 0145	·160 0249	·24903	·987 4368	·162 3214	·164 5031	·07891	·986 7379	38
23	·158 0863	·160 0995	·24612	·987 4253	·162 3932	·164 5778	·07615	·986 7261	37
24	·158 1581	·160 1740	·24321	·987 4138	·162 4650	·164 6525	·07340	·986 7143	36
25	0·158 2299	0·160 2486	6·24030	0·987 4023	0·162 5367	0·164 7272	6·07064	0·986 7025	35
26	·158 3017	·160 3232	·23740	·987 3908	·162 6085	·164 8019	·06789	·986 6907	34
27	·158 3735	·160 3978	·23450	·987 3793	·162 6802	·164 8766	·06514	·986 6788	33
28	·158 4453	·160 4724	·23160	·987 3678	·162 7520	·164 9513	·06240	·986 6670	32
29	·158 5171	·160 5470	·22871	·987 3562	·162 8237	·165 0260	·05965	·986 6552	31
30	0·158 5889	0·160 6216	6·22581	0·987 3447	0·162 8955	0·165 1007	6·05691	0·986 6433	30
31	·158 6607	·160 6962	·22292	·987 3332	·162 9672	·165 1754	·05417	·986 6315	29
32	·158 7325	·160 7708	·22003	·987 3216	·163 0390	·165 2501	·05143	·986 6196	28
33	·158 8043	·160 8454	·21715	·987 3101	·163 1107	·165 3248	·04870	·986 6078	27
34	·158 8761	·160 9200	·21427	·987 2985	·163 1825	·165 3995	·04597	·986 5959	26
35	0·158 9479	0·160 9946	6·21139	0·987 2870	0·163 2542	0·165 4742	6·04324	0·986 5840	25
36	·159 0197	·161 0692	·20851	·987 2754	·163 3260	·165 5489	·04051	·986 5722	24
37	·159 0915	·161 1438	·20564	·987 2638	·163 3977	·165 6236	·03779	·986 5603	23
38	·159 1633	·161 2184	·20276	·987 2523	·163 4695	·165 6984	·03506	·986 5484	22
39	·159 2351	·161 2931	·19989	·987 2407	·163 5412	·165 7731	·03234	·986 5365	21
40	0·159 3069	0·161 3677	6·19703	0·987 2291	0·163 6129	0·165 8478	6·02962	0·986 5246	20
41	·159 3787	·161 4423	·19416	·987 2175	·163 6847	·165 9225	·02691	·986 5127	19
42	·159 4505	·161 5169	·19130	·987 2059	·163 7564	·165 9972	·02420	·986 5008	18
43	·159 5222	·161 5915	·18844	·987 1943	·163 8282	·166 0720	·02149	·986 4889	17
44	·159 5940	·161 6662	·18559	·987 1827	·163 8999	·166 1467	·01878	·986 4770	16
45	0·159 6658	0·161 7408	6·18273	0·987 1711	0·163 9716	0·166 2214	6·01607	0·986 4651	15
46	·159 7376	·161 8154	·17988	·987 1595	·164 0434	·166 2962	·01337	·986 4531	14
47	·159 8094	·161 8900	·17703	·987 1479	·164 1151	·166 3709	·01067	·986 4412	13
48	·159 8812	·161 9647	·17419	·987 1363	·164 1868	·166 4456	·00797	·986 4293	12
49	·159 9530	·162 0393	·17134	·987 1246	·164 2586	·166 5204	·00527	·986 4173	11
50	0·160 0248	0·162 1139	6·16850	0·987 1130	0·164 3303	0·166 5951	6·00258	0·986 4054	10
51	·160 0965	·162 1886	·16566	·987 1014	·164 4020	·166 6699	5·99989	·986 3934	09
52	·160 1683	·162 2632	·16283	·987 0897	·164 4738	·166 7446	·99720	·986 3815	08
53	·160 2401	·162 3378	·15999	·987 0781	·164 5455	·166 8193	·99451	·986 3695	07
54	·160 3119	·162 4125	·15716	·987 0664	·164 6172	·166 8941	·99182	·986 3575	06
55	0·160 3837	0·162 4871	6·15433	0·987 0547	0·164 6890	0·166 9688	5·98914	0·986 3455	05
56	·160 4555	·162 5618	·15151	·987 0431	·164 7607	·167 0436	·98646	·986 3336	04
57	·160 5272	·162 6364	·14869	·987 0314	·164 8324	·167 1183	·98378	·986 3216	03
58	·160 5990	·162 7110	·14586	·987 0197	·164 9042	·167 1931	·98111	·986 3096	02
59	·160 6708	·162 7857	·14305	·987 0081	·164 9759	·167 2679	·97844	·986 2976	01
60	0·160 7426	0·162 8603	6·14023	0·986 9964	0·165 0476	0·167 3426	5·97576	0·986 2856	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	717–719	747–745	281–297	117–113	717–718	748–746	267–281	120–117	d

$5^{\mathrm{h}}\ 23^{\mathrm{m}}$ $5^{\mathrm{h}}\ 22^{\mathrm{m}}$

$0^{h}\ 38^{m}$ $0^{h}\ 39^{m}$

d	718–716	747–749	267–253	120–123	717–716	748–750	254–241	123–126	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·165 0476	0·167 3426	5·97576	0·986 2856	0·169 3495	0·171 8314	5·81966	0·985 5561	60
01	·165 1193	·167 4174	·97310	·986 2736	·169 4212	·171 9063	·81712	·985 5437	59
02	·165 1911	·167 4921	·97043	·986 2616	·169 4928	·171 9812	·81459	·985 5314	58
03	·165 2628	·167 5669	·96777	·986 2496	·169 5645	·172 0560	·81206	·985 5191	57
04	·165 3345	·167 6417	·96510	·986 2375	·169 6362	·172 1309	·80953	·985 5068	56
05	0·165 4062	0·167 7164	5·96245	0·986 2255	0·169 7079	0·172 2058	5·80701	0·985 4944	55
06	·165 4779	·167 7912	·95979	·986 2135	·169 7795	·172 2807	·80448	·985 4821	54
07	·165 5497	·167 8660	·95713	·986 2015	·169 8512	·172 3556	·80196	·985 4697	53
08	·165 6214	·167 9407	·95448	·986 1894	·169 9228	·172 4304	·79944	·985 4574	52
09	·165 6931	·168 0155	·95183	·986 1774	·169 9945	·172 5053	·79692	·985 4450	51
10	0·165 7648	0·168 0903	5·94918	0·986 1653	0·170 0662	0·172 5802	5·79441	0·985 4326	50
11	·165 8365	·168 1651	·94654	·986 1533	·170 1378	·172 6551	·79189	·985 4203	49
12	·165 9082	·168 2398	·94390	·986 1412	·170 2095	·172 7300	·78938	·985 4079	48
13	·165 9800	·168 3146	·94125	·986 1291	·170 2812	·172 8049	·78687	·985 3955	47
14	·166 0517	·168 3894	·93862	·986 1171	·170 3528	·172 8798	·78437	·985 3831	46
15	0·166 1234	0·168 4642	5·93598	0·986 1050	0·170 4245	0·172 9547	5·78186	0·985 3707	45
16	·166 1951	·168 5390	·93335	·986 0929	·170 4961	·173 0296	·77936	·985 3583	44
17	·166 2668	·168 6138	·93071	·986 0808	·170 5678	·173 1045	·77686	·985 3459	43
18	·166 3385	·168 6886	·92808	·986 0687	·170 6394	·173 1794	·77436	·985 3335	42
19	·166 4102	·168 7634	·92546	·986 0566	·170 7111	·173 2543	·77186	·985 3211	41
20	0·166 4819	0·168 8381	5·92283	0·986 0445	0·170 7828	0·173 3292	5·76937	0·985 3087	40
21	·166 5536	·168 9129	·92021	·986 0324	·170 8544	·173 4041	·76688	·985 2963	39
22	·166 6253	·168 9877	·91759	·986 0203	·170 9261	·173 4790	·76439	·985 2839	38
23	·166 6970	·169 0625	·91497	·986 0082	·170 9977	·173 5539	·76190	·985 2714	37
24	·166 7687	·169 1373	·91236	·985 9960	·171 0694	·173 6288	·75941	·985 2590	36
25	0·166 8404	0·169 2121	5·90974	0·985 9839	0·171 1410	0·173 7037	5·75693	0·985 2465	35
26	·166 9122	·169 2869	·90713	·985 9718	·171 2127	·173 7787	·75445	·985 2341	34
27	·166 9839	·169 3618	·90452	·985 9596	·171 2843	·173 8536	·75197	·985 2216	33
28	·167 0556	·169 4366	·90191	·985 9475	·171 3560	·173 9285	·74949	·985 2092	32
29	·167 1273	·169 5114	·89931	·985 9353	·171 4276	·174 0034	·74701	·985 1967	31
30	0·167 1990	0·169 5862	5·89671	0·985 9232	0·171 4992	0·174 0784	5·74454	0·985 1843	30
31	·167 2707	·169 6610	·89411	·985 9110	·171 5709	·174 1533	·74207	·985 1718	29
32	·167 3423	·169 7358	·89151	·985 8988	·171 6425	·174 2282	·73960	·985 1593	28
33	·167 4140	·169 8106	·88891	·985 8867	·171 7142	·174 3031	·73713	·985 1468	27
34	·167 4857	·169 8855	·88632	·985 8745	·171 7858	·174 3781	·73467	·985 1343	26
35	0·167 5574	0·169 9603	5·88373	0·985 8623	0·171 8575	0·174 4530	5·73220	0·985 1218	25
36	·167 6291	·170 0351	·88114	·985 8501	·171 9291	·174 5279	·72974	·985 1093	24
37	·167 7008	·170 1099	·87855	·985 8379	·172 0007	·174 6029	·72728	·985 0968	23
38	·167 7725	·170 1848	·87597	·985 8257	·172 0724	·174 6778	·72483	·985 0843	22
39	·167 8442	·170 2596	·87338	·985 8135	·172 1440	·174 7528	·72237	·985 0718	21
40	0·167 9159	0·170 3344	5·87080	0·985 8013	0·172 2156	0·174 8277	5·71992	0·985 0593	20
41	·167 9876	·170 4092	·86823	·985 7891	·172 2873	·174 9026	·71747	·985 0467	19
42	·168 0593	·170 4841	·86565	·985 7769	·172 3589	·174 9776	·71502	·985 0342	18
43	·168 1310	·170 5589	·86308	·985 7647	·172 4306	·175 0525	·71257	·985 0217	17
44	·168 2026	·170 6338	·86051	·985 7524	·172 5022	·175 1275	·71013	·985 0091	16
45	0·168 2743	0·170 7086	5·85794	0·985 7402	0·172 5738	0·175 2025	5·70768	0·984 9966	15
46	·168 3460	·170 7834	·85537	·985 7280	·172 6454	·175 2774	·70524	·984 9840	14
47	·168 4177	·170 8583	·85280	·985 7157	·172 7171	·175 3524	·70280	·984 9715	13
48	·168 4894	·170 9331	·85024	·985 7035	·172 7887	·175 4273	·70037	·984 9589	12
49	·168 5611	·171 0080	·84768	·985 6912	·172 8603	·175 5023	·69793	·984 9463	11
50	0·168 6327	0·171 0828	5·84512	0·985 6790	0·172 9320	0·175 5772	5·69550	0·984 9338	10
51	·168 7044	·171 1577	·84257	·985 6667	·173 0036	·175 6522	·69307	·984 9212	09
52	·168 7761	·171 2325	·84001	·985 6544	·173 0752	·175 7272	·69064	·984 9086	08
53	·168 8478	·171 3074	·83746	·985 6421	·173 1468	·175 8021	·68821	·984 8960	07
54	·168 9195	·171 3822	·83491	·985 6299	·173 2185	·175 8771	·68579	·984 8834	06
55	0·168 9911	0·171 4571	5·83236	0·985 6176	0·173 2901	0·175 9521	5·68337	0·984 8708	05
56	·169 0628	·171 5320	·82982	·985 6053	·173 3617	·176 0271	·68094	·984 8582	04
57	·169 1345	·171 6068	·82727	·985 5930	·173 4333	·176 1020	·67853	·984 8456	03
58	·169 2062	·171 6817	·82473	·985 5807	·173 5049	·176 1770	·67611	·984 8330	02
59	·169 2778	·171 7566	·82219	·985 5684	·173 5766	·176 2520	·67369	·984 8204	01
60	0·169 3495	0·171 8314	5·81966	0·985 5561	0·173 6482	0·176 3270	5·67128	0·984 8078	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	716–718	749–747	253–267	123–120	716–717	750–748	241–254	126–123	d

$5^{h}\ 21^{m}$ $5^{h}\ 20^{m}$

$0^h\ 40^m$ $0^h\ 41^m$

d	717–715	749–751	2411–2298	126–130	716–715	751–753	2295–2191	129–133	d
	sin	tan	cot	cos	sin	tan	cot	cos	
s									
00	0·173 6482	0·176 3270	5·671 282	0·984 8078	0·177 9435	0·180 8295	5·530 072	0·984 0407	60
01	·173 7198	·176 4020	·668 871	·984 7951	·178 0151	·180 9046	·527 777	·984 0278	59
02	·173 7914	·176 4770	·666 462	·984 7825	·178 0867	·180 9797	·525 483	·984 0148	58
03	·173 8630	·176 5519	·664 056	·984 7698	·178 1582	·181 0548	·523 191	·984 0019	57
04	·173 9346	·176 6269	·661 651	·984 7572	·178 2298	·181 1299	·520 900	·983 9889	56
05	0·174 0063	0·176 7019	5·659 248	0·984 7445	0·178 3013	0·181 2050	5·518 612	0·983 9759	55
06	·174 0779	·176 7769	·656 847	·984 7319	·178 3729	·181 2801	·516 325	·983 9630	54
07	·174 1495	·176 8519	·654 448	·984 7192	·178 4445	·181 3552	·514 041	·983 9500	53
08	·174 2211	·176 9269	·652 052	·984 7066	·178 5160	·181 4303	·511 758	·983 9370	52
09	·174 2927	·177 0019	·649 657	·984 6939	·178 5876	·181 5054	·509 477	·983 9240	51
10	0·174 3643	0·177 0769	5·647 264	0·984 6812	0·178 6591	0·181 5806	5·507 198	0·983 9110	50
11	·174 4359	·177 1519	·644 873	·984 6685	·178 7307	·181 6557	·504 920	·983 8980	49
12	·174 5075	·177 2269	·642 484	·984 6558	·178 8022	·181 7308	·502 645	·983 8850	48
13	·174 5791	·177 3019	·640 097	·984 6431	·178 8738	·181 8059	·500 371	·983 8720	47
14	·174 6507	·177 3769	·637 712	·984 6304	·178 9453	·181 8811	·498 099	·983 8590	46
15	0·174 7223	0·177 4519	5·635 329	0·984 6177	0·179 0169	0·181 9562	5·495 829	0·983 8460	45
16	·174 7939	·177 5270	·632 947	·984 6050	·179 0884	·182 0313	·493 560	·983 8330	44
17	·174 8655	·177 6020	·630 568	·984 5923	·179 1600	·182 1064	·491 294	·983 8200	43
18	·174 9371	·177 6770	·628 191	·984 5796	·179 2315	·182 1816	·489 029	·983 8069	42
19	·175 0087	·177 7520	·625 816	·984 5669	·179 3030	·182 2567	·486 766	·983 7939	41
20	0·175 0803	0·177 8270	5·623 442	0·984 5542	0·179 3746	0·182 3319	5·484 505	0·983 7808	40
21	·175 1519	·177 9021	·621 071	·984 5414	·179 4461	·182 4070	·482 246	·983 7678	39
22	·175 2235	·177 9771	·618 701	·984 5287	·179 5177	·182 4821	·479 988	·983 7547	38
23	·175 2951	·178 0521	·616 334	·984 5159	·179 5892	·182 5573	·477 733	·983 7417	37
24	·175 3667	·178 1271	·613 968	·984 5032	·179 6607	·182 6324	·475 479	·983 7286	36
25	0·175 4383	0·178 2022	5·611 604	0·984 4904	0·179 7323	0·182 7076	5·473 227	0·983 7156	35
26	·175 5099	·178 2772	·609 242	·984 4777	·179 8038	·182 7827	·470 976	·983 7025	34
27	·175 5815	·178 3522	·606 883	·984 4649	·179 8754	·182 8579	·468 728	·983 6894	33
28	·175 6531	·178 4273	·604 525	·984 4521	·179 9469	·182 9330	·466 481	·983 6763	32
29	·175 7247	·178 5023	·602 169	·984 4393	·180 0184	·183 0082	·464 236	·983 6632	31
30	0·175 7963	0·178 5773	5·599 815	0·984 4266	0·180 0900	0·183 0834	5·461 993	0·983 6501	30
31	·175 8679	·178 6524	·597 462	·984 4138	·180 1615	·183 1585	·459 752	·983 6370	29
32	·175 9395	·178 7274	·595 112	·984 4010	·180 2330	·183 2337	·457 512	·983 6239	28
33	·176 0110	·178 8025	·592 764	·984 3882	·180 3046	·183 3088	·455 274	·983 6108	27
34	·176 0826	·178 8775	·590 417	·984 3754	·180 3761	·183 3840	·453 038	·983 5977	26
35	0·176 1542	0·178 9526	5·588 073	0·984 3626	0·180 4476	0·183 4592	5·450 804	0·983 5846	25
36	·176 2258	·179 0276	·585 730	·984 3498	·180 5191	·183 5343	·448 572	·983 5715	24
37	·176 2974	·179 1027	·583 389	·984 3370	·180 5907	·183 6095	·446 341	·983 5583	23
38	·176 3690	·179 1777	·581 051	·984 3241	·180 6622	·183 6847	·444 112	·983 5452	22
39	·176 4405	·179 2528	·578 714	·984 3113	·180 7337	·183 7599	·441 885	·983 5321	21
40	0·176 5121	0·179 3279	5·576 379	0·984 2985	0·180 8052	0·183 8350	5·439 659	0·983 5189	20
41	·176 5837	·179 4029	·574 046	·984 2856	·180 8768	·183 9102	·437 435	·983 5058	19
42	·176 6553	·179 4780	·571 714	·984 2728	·180 9483	·183 9854	·435 214	·983 4926	18
43	·176 7269	·179 5530	·569 385	·984 2599	·181 0198	·184 0606	·432 993	·983 4794	17
44	·176 7984	·179 6281	·567 057	·984 2471	·181 0913	·184 1358	·430 775	·983 4663	16
45	0·176 8700	0·179 7032	5·564 732	0·984 2342	0·181 1629	0·184 2110	5·428 558	0·983 4531	15
46	·176 9416	·179 7783	·562 408	·984 2214	·181 2344	·184 2862	·426 343	·983 4399	14
47	·177 0132	·179 8533	·560 086	·984 2085	·181 3059	·184 3614	·424 130	·983 4268	13
48	·177 0847	·179 9284	·557 766	·984 1956	·181 3774	·184 4365	·421 919	·983 4136	12
49	·177 1563	·180 0035	·555 448	·984 1827	·181 4489	·184 5117	·419 709	·983 4004	11
50	0·177 2279	0·180 0786	5·553 132	0·984 1698	0·181 5204	0·184 5869	5·417 501	0·983 3872	10
51	·177 2995	·180 1536	·550 818	·984 1570	·181 5919	·184 6621	·415 295	·983 3740	09
52	·177 3710	·180 2287	·548 505	·984 1441	·181 6635	·184 7373	·413 091	·983 3608	08
53	·177 4426	·180 3038	·546 195	·984 1312	·181 7350	·184 8126	·410 888	·983 3475	07
54	·177 5142	·180 3789	·543 886	·984 1182	·181 8065	·184 8878	·408 687	·983 3343	06
55	0·177 5857	0·180 4540	5·541 579	0·984 1053	0·181 8780	0·184 9630	5·406 488	0·983 3211	05
56	·177 6573	·180 5291	·539 274	·984 0924	·181 9495	·185 0382	·404 290	·983 3079	04
57	·177 7289	·180 6042	·536 971	·984 0795	·182 0210	·185 1134	·402 094	·983 2946	03
58	·177 8004	·180 6793	·534 670	·984 0666	·182 0925	·185 1886	·399 900	·983 2814	02
59	·177 8720	·180 7544	·532 370	·984 0536	·182 1640	·185 2638	·397 708	·983 2682	01
60	0·177 9435	0·180 8295	5·530 072	0·984 0407	0·182 2355	0·185 3390	5·395 517	0·983 2549	00
									s
	cos	cot	tan	sin	cos	cot	tan	sin	
d	715–717	751–749	2298–2411	130–126	715–716	753–751	2191–2295	133–129	d

$5^h\ 19^m$ $5^h\ 18^m$

$0^{h}\ 42^{m}$ $0^{h}\ 43^{m}$

d	715–714	752–754	2189–2091	132–136	715–713	753–755	2090–1998	135–139	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·182 2355	0·185 3390	5·395 517	0·983 2549	0·186 5240	0·189 8559	5·267 152	0·982 4504	60
01	·182 3070	·185 4143	·393 328	·983 2417	·186 5955	·189 9313	·265 062	·982 4368	59
02	·182 3785	·185 4895	·391 141	·983 2284	·186 6669	·190 0066	·262 974	·982 4233	58
03	·182 4500	·185 5647	·388 956	·983 2151	·186 7384	·190 0820	·260 888	·982 4097	57
04	·182 5215	·185 6399	·386 772	·983 2019	·186 8098	·190 1573	·258 804	·982 3961	56
05	0·182 5930	0·185 7152	5·384 590	0·983 1886	0·186 8813	0·190 2327	5·256 720	0·982 3825	55
06	·182 6645	·185 7904	·382 409	·983 1753	·186 9527	·190 3080	·254 639	·982 3689	54
07	·182 7360	·185 8656	·380 231	·983 1620	·187 0241	·190 3834	·252 559	·982 3553	53
08	·182 8075	·185 9409	·378 054	·983 1487	·187 0956	·190 4587	·250 481	·982 3417	52
09	·182 8790	·186 0161	·375 879	·983 1354	·187 1670	·190 5341	·248 404	·982 3281	51
10	0·182 9505	0·186 0913	5·373 705	0·983 1221	0·187 2384	0·190 6095	5·246 329	0·982 3145	50
11	·183 0220	·186 1666	·371 533	·983 1088	·187 3099	·190 6848	·244 256	·982 3009	49
12	·183 0935	·186 2418	·369 363	·983 0955	·187 3813	·190 7602	·242 184	·982 2873	48
13	·183 1650	·186 3171	·367 195	·983 0822	·187 4527	·190 8356	·240 113	·982 2736	47
14	·183 2365	·186 3923	·365 028	·983 0689	·187 5242	·190 9109	·238 044	·982 2600	46
15	0·183 3080	0·186 4676	5·362 863	0·983 0555	0·187 5956	0·190 9863	5·235 977	0·982 2463	45
16	·183 3795	·186 5428	·360 699	·983 0422	·187 6670	·191 0617	·233 912	·982 2327	44
17	·183 4510	·186 6181	·358 538	·983 0289	·187 7385	·191 1371	·231 847	·982 2191	43
18	·183 5224	·186 6933	·356 378	·983 0155	·187 8099	·191 2125	·229 785	·982 2054	42
19	·183 5939	·186 7686	·354 219	·983 0022	·187 8813	·191 2878	·227 724	·982 1917	41
20	0·183 6654	0·186 8439	5·352 063	0·982 9888	0·187 9528	0·191 3632	5·225 665	0·982 1781	40
21	·183 7369	·186 9191	·349 908	·982 9755	·188 0242	·191 4386	·223 607	·982 1644	39
22	·183 8084	·186 9944	·347 754	·982 9621	·188 0956	·191 5140	·221 551	·982 1507	38
23	·183 8799	·187 0696	·345 603	·982 9487	·188 1670	·191 5894	·219 496	·982 1370	37
24	·183 9514	·187 1449	·343 453	·982 9353	·188 2385	·191 6648	·217 443	·982 1234	36
25	0·184 0228	0·187 2202	5·341 304	0·982 9220	0·188 3099	0·191 7402	5·215 391	0·982 1097	35
26	·184 0943	·187 2955	·339 158	·982 9086	·188 3813	·191 8156	·213 341	·982 0960	34
27	·184 1658	·187 3707	·337 013	·982 8952	·188 4527	·191 8910	·211 293	·982 0823	33
28	·184 2373	·187 4460	·334 870	·982 8818	·188 5241	·191 9664	·209 246	·982 0686	32
29	·184 3087	·187 5213	·332 728	·982 8684	·188 5955	·192 0418	·207 201	·982 0548	31
30	0·184 3802	0·187 5966	5·330 588	0·982 8550	0·188 6670	0·192 1172	5·205 157	0·982 0411	30
31	·184 4517	·187 6718	·328 450	·982 8416	·188 7384	·192 1926	·203 115	·982 0274	29
32	·184 5232	·187 7471	·326 313	·982 8282	·188 8098	·192 2680	·201 074	·982 0137	28
33	·184 5946	·187 8224	·324 178	·982 8147	·188 8812	·192 3434	·199 035	·981 9999	27
34	·184 6661	·187 8977	·322 045	·982 8013	·188 9526	·192 4188	·196 997	·981 9862	26
35	0·184 7376	0·187 9730	5·319 913	0·982 7879	0·189 0240	0·192 4942	5·194 961	0·981 9725	25
36	·184 8091	·188 0483	·317 783	·982 7744	·189 0954	·192 5696	·192 926	·981 9587	24
37	·184 8805	·188 1236	·315 655	·982 7610	·189 1669	·192 6451	·190 893	·981 9450	23
38	·184 9520	·188 1989	·313 528	·982 7476	·189 2383	·192 7205	·188 862	·981 9312	22
39	·185 0235	·188 2742	·311 403	·982 7341	·189 3097	·192 7959	·186 832	·981 9174	21
40	0·185 0949	0·188 3495	5·309 279	0·982 7206	0·189 3811	0·192 8713	5·184 804	0·981 9037	20
41	·185 1664	·188 4248	·307 157	·982 7072	·189 4525	·192 9468	·182 777	·981 8899	19
42	·185 2379	·188 5001	·305 037	·982 6937	·189 5239	·193 0222	·180 751	·981 8761	18
43	·185 3093	·188 5754	·302 919	·982 6802	·189 5953	·193 0976	·178 727	·981 8623	17
44	·185 3808	·188 6507	·300 802	·982 6668	·189 6667	·193 1731	·176 705	·981 8485	16
45	0·185 4522	0·188 7260	5·298 687	0·982 6533	0·189 7381	0·193 2485	5·174 684	0·981 8347	15
46	·185 5237	·188 8013	·296 573	·982 6398	·189 8095	·193 3239	·172 665	·981 8209	14
47	·185 5952	·188 8766	·294 461	·982 6263	·189 8809	·193 3994	·170 647	·981 8071	13
48	·185 6666	·188 9520	·292 350	·982 6128	·189 9523	·193 4748	·168 631	·981 7933	12
49	·185 7381	·189 0273	·290 242	·982 5993	·190 0237	·193 5503	·166 616	·981 7795	11
50	0·185 8095	0·189 1026	5·288 135	0·982 5858	0·190 0951	0·193 6257	5·164 603	0·981 7657	10
51	·185 8810	·189 1779	·286 029	·982 5723	·190 1665	·193 7012	·162 591	·981 7519	09
52	·185 9524	·189 2533	·283 925	·982 5587	·190 2379	·193 7766	·160 581	·981 7380	08
53	·186 0239	·189 3286	·281 823	·982 5452	·190 3093	·193 8521	·158 573	·981 7242	07
54	·186 0953	·189 4039	·279 722	·982 5317	·190 3807	·193 9275	·156 565	·981 7103	06
55	0·186 1668	0·189 4792	5·277 623	0·982 5182	0·190 4521	0·194 0030	5·154 560	0·981 6965	05
56	·186 2382	·189 5546	·275 526	·982 5046	·190 5234	·194 0784	·152 556	·981 6826	04
57	·186 3097	·189 6299	·273 430	·982 4911	·190 5948	·194 1539	·150 553	·981 6688	03
58	·186 3811	·189 7052	·271 335	·982 4775	·190 6662	·194 2294	·148 552	·981 6549	02
59	·186 4526	·189 7806	·269 243	·982 4640	·190 7376	·194 3048	·146 552	·981 6411	01
60	0·186 5240	0·189 8559	5·267 152	0·982 4504	0·190 8090	0·194 3803	5·144 554	0·981 6272	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	714–715	754–752	2091–2189	136–132	713–715	755–753	1998–2090	139–135	d

$5^{h}\ 17^{m}$ $5^{h}\ 16^{m}$

0^{h} 44^{m} 0^{h} 45^{m}

d	714–713	754–756	1997–1912	139–142	714–712	756–758	1910–1830	142–145	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·190 8090	0·194 3803	5·144 554	0·981 6272	0·195 0903	0·198 9124	5·027 339	0·980 7853	60
01	·190 8804	·194 4558	·142 557	·981 6133	·195 1616	·198 9880	·025 429	·980 7711	59
02	·190 9518	·194 5313	·140 562	·981 5994	·195 2330	·199 0636	·023 521	·980 7569	58
03	·191 0231	·194 6067	·138 568	·981 5855	·195 3043	·199 1392	·021 614	·980 7427	57
04	·191 0945	·194 6822	·136 576	·981 5716	·195 3756	·199 2148	·019 708	·980 7285	56
05	0·191 1659	0·194 7577	5·134 586	0·981 5577	0·195 4469	0·199 2904	5·017 803	0·980 7143	55
06	·191 2373	·194 8332	·132 596	·981 5438	·195 5183	·199 3660	·015 900	·980 7001	54
07	·191 3087	·194 9086	·130 609	·981 5299	·195 5896	·199 4416	·013 999	·980 6858	53
08	·191 3801	·194 9841	·128 622	·981 5160	·195 6609	·199 5172	·012 098	·980 6716	52
09	·191 4514	·195 0596	·126 638	·981 5021	·195 7322	·199 5929	·010 200	·980 6574	51
10	0·191 5228	0·195 1351	5·124 654	0·981 4882	0·195 8035	0·199 6685	5·008 302	0·980 6431	50
11	·191 5942	·195 2106	·122 672	·981 4742	·195 8748	·199 7441	·006 406	·980 6289	49
12	·191 6656	·195 2861	·120 692	·981 4603	·195 9461	·199 8197	·004 511	·980 6147	48
13	·191 7369	·195 3616	·118 713	·981 4464	·196 0175	·199 8953	·002 618	·980 6004	47
14	·191 8083	·195 4371	·116 736	·981 4324	·196 0888	·199 9710	5·000 726	·980 5861	46
15	0·191 8797	0·195 5126	5·114 760	0·981 4185	0·196 1601	0·200 0466	4·998 835	0·980 5719	45
16	·191 9510	·195 5881	·112 786	·981 4045	·196 2314	·200 1222	·996 946	·980 5576	44
17	·192 0224	·195 6636	·110 813	·981 3905	·196 3027	·200 1979	·995 058	·980 5433	43
18	·192 0938	·195 7391	·108 841	·981 3766	·196 3740	·200 2735	·993 172	·980 5291	42
19	·192 1651	·195 8146	·106 871	·981 3626	·196 4453	·200 3492	·991 286	·980 5148	41
20	0·192 2365	0·195 8901	5·104 902	0·981 3486	0·196 5166	0·200 4248	4·989 403	0·980 5005	40
21	·192 3079	·195 9656	·102 935	·981 3346	·196 5879	·200 5004	·987 520	·980 4862	39
22	·192 3792	·196 0412	·100 970	·981 3207	·196 6592	·200 5761	·985 639	·980 4719	38
23	·192 4506	·196 1167	·099 005	·981 3067	·196 7305	·200 6517	·983 760	·980 4576	37
24	·192 5220	·196 1922	·097 043	·981 2927	·196 8018	·200 7274	·981 881	·980 4433	36
25	0·192 5933	0·196 2677	5·095 081	0·981 2787	0·196 8731	0·200 8030	4·980 004	0·980 4290	35
26	·192 6647	·196 3432	·093 121	·981 2647	·196 9444	·200 8787	·978 129	·980 4147	34
27	·192 7360	·196 4188	·091 163	·981 2506	·197 0157	·200 9544	·976 255	·980 4003	33
28	·192 8074	·196 4943	·089 206	·981 2366	·197 0870	·201 0300	·974 382	·980 3860	32
29	·192 8788	·196 5698	·087 251	·981 2226	·197 1583	·201 1057	·972 510	·980 3717	31
30	0·192 9501	0·196 6454	5·085 297	0·981 2086	0·197 2296	0·201 1813	4·970 640	0·980 3573	30
31	·193 0215	·196 7209	·083 344	·981 1945	·197 3009	·201 2570	·968 771	·980 3430	29
32	·193 0928	·196 7964	·081 393	·981 1805	·197 3722	·201 3327	·966 904	·980 3286	28
33	·193 1642	·196 8720	·079 443	·981 1664	·197 4435	·201 4083	·965 038	·980 3143	27
34	·193 2355	·196 9475	·077 495	·981 1524	·197 5148	·201 4840	·963 173	·980 2999	26
35	0·193 3069	0·197 0231	5·075 548	0·981 1383	0·197 5861	0·201 5597	4·961 309	0·980 2855	25
36	·193 3782	·197 0986	·073 602	·981 1243	·197 6573	·201 6354	·959 447	·980 2712	24
37	·193 4496	·197 1742	·071 659	·981 1102	·197 7286	·201 7110	·957 587	·980 2568	23
38	·193 5209	·197 2497	·069 716	·981 0961	·197 7999	·201 7867	·955 727	·980 2424	22
39	·193 5923	·197 3253	·067 775	·981 0821	·197 8712	·201 8624	·953 869	·980 2280	21
40	0·193 6636	0·197 4008	5·065 835	0·981 0680	0·197 9425	0·201 9381	4·952 012	0·980 2136	20
41	·193 7350	·197 4764	·063 897	·981 0539	·198 0138	·202 0138	·950 157	·980 1992	19
42	·193 8063	·197 5519	·061 960	·981 0398	·198 0850	·202 0895	·948 303	·980 1848	18
43	·193 8777	·197 6275	·060 025	·981 0257	·198 1563	·202 1652	·946 450	·980 1704	17
44	·193 9490	·197 7031	·058 091	·981 0116	·198 2276	·202 2409	·944 599	·980 1560	16
45	0·194 0203	0·197 7786	5·056 158	0·980 9975	0·198 2989	0·202 3166	4·942 749	0·980 1416	15
46	·194 0917	·197 8542	·054 227	·980 9834	·198 3702	·202 3923	·940 900	·980 1272	14
47	·194 1630	·197 9298	·052 297	·980 9693	·198 4414	·202 4680	·939 053	·980 1127	13
48	·194 2344	·198 0053	·050 369	·980 9552	·198 5127	·202 5437	·937 207	·980 0983	12
49	·194 3057	·198 0809	·048 442	·980 9410	·198 5840	·202 6194	·935 362	·980 0839	11
50	0·194 3770	0·198 1565	5·046 517	0·980 9269	0·198 6553	0·202 6951	4·933 519	0·980 0694	10
51	·194 4484	·198 2321	·044 593	·980 9128	·198 7265	·202 7708	·931 677	·980 0550	09
52	·194 5197	·198 3076	·042 670	·980 8986	·198 7978	·202 8465	·929 836	·980 0405	08
53	·194 5910	·198 3832	·040 749	·980 8845	·198 8691	·202 9222	·927 996	·980 0261	07
54	·194 6624	·198 4588	·038 829	·980 8703	·198 9403	·202 9979	·926 158	·980 0116	06
55	0·194 7337	0·198 5344	5·036 911	0·980 8562	0·199 0116	0·203 0737	4·924 321	0·979 9971	05
56	·194 8050	·198 6100	·034 994	·980 8420	·199 0829	·203 1494	·922 486	·979 9827	04
57	·194 8763	·198 6856	·033 078	·980 8278	·199 1541	·203 2251	·920 652	·979 9682	03
58	·194 9477	·198 7612	·031 164	·980 8136	·199 2254	·203 3008	·918 819	·979 9537	02
59	·195 0190	·198 8368	·029 251	·980 7995	·199 2967	·203 3766	·916 987	·979 9392	01
60	0·195 0903	0·198 9124	5·027 339	0·980 7853	0·199 3679	0·203 4523	4·915 157	0·979 9247	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	713–714	756–754	1912–1997	142–139	712–714	758–756	1830–1910	145–142	d

5^{h} 15^{m} 5^{h} 14^{m}

0^h 46^m | 0^h 47^m

d	713–712	757–759	1829–1755	145–148	712–711	758–761	1753–1683	148–151	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·199 3679	0·203 4523	4·915 157	0·979 9247	0·203 6418	0·208 0003	4·807 685	0·979 0455	60
01	·199 4392	·203 5280	·913 328	·979 9102	·203 7129	·208 0762	·805 932	·979 0307	59
02	·199 5105	·203 6038	·911 500	·979 8957	·203 7841	·208 1520	·804 181	·979 0158	58
03	·199 5817	·203 6795	·909 674	·979 8812	·203 8553	·208 2279	·802 430	·979 0010	57
04	·199 6530	·203 7552	·907 849	·979 8667	·203 9265	·208 3038	·800 681	·978 9862	56
05	0·199 7242	0·203 8310	4·906 025	0·979 8521	0·203 9977	0·208 3797	4·798 933	0·978 9714	55
06	·199 7955	·203 9067	·904 203	·979 8376	·204 0689	·208 4556	·797 186	·978 9565	54
07	·199 8667	·203 9825	·902 382	·979 8231	·204 1401	·208 5314	·795 440	·978 9417	53
08	·199 9380	·204 0582	·900 562	·979 8086	·204 2113	·208 6073	·793 696	·978 9268	52
09	·200 0093	·204 1340	·898 743	·979 7940	·204 2825	·208 6832	·791 952	·978 9120	51
10	0·200 0805	0·204 2097	4·896 926	0·979 7795	0·204 3537	0·208 7591	4·790 210	0·978 8971	50
11	·200 1518	·204 2855	·895 110	·979 7649	·204 4249	·208 8350	·788 470	·978 8823	49
12	·200 2230	·204 3612	·893 296	·979 7504	·204 4961	·208 9109	·786 730	·978 8674	48
13	·200 2943	·204 4370	·891 482	·979 7358	·204 5672	·208 9868	·784 992	·978 8525	47
14	·200 3655	·204 5128	·889 670	·979 7212	·204 6384	·209 0627	·783 254	·978 8376	46
15	0·200 4367	0·204 5885	4·887 859	0·979 7066	0·204 7096	0·209 1386	4·781 518	0·978 8228	45
16	·200 5080	·204 6643	·886 050	·979 6921	·204 7808	·209 2145	·779 784	·978 8079	44
17	·200 5792	·204 7401	·884 242	·979 6775	·204 8520	·209 2904	·778 050	·978 7930	43
18	·200 6505	·204 8158	·882 435	·979 6629	·204 9231	·209 3663	·776 318	·978 7781	42
19	·200 7217	·204 8916	·880 629	·979 6483	·204 9943	·209 4422	·774 587	·978 7632	41
20	0·200 7930	0·204 9674	4·878 825	0·979 6337	0·205 0655	0·209 5181	4·772 857	0·978 7483	40
21	·200 8642	·205 0432	·877 022	·979 6191	·205 1367	·209 5940	·771 128	·978 7333	39
22	·200 9354	·205 1190	·875 220	·979 6045	·205 2079	·209 6700	·769 400	·978 7184	38
23	·201 0067	·205 1947	·873 419	·979 5899	·205 2790	·209 7459	·767 674	·978 7035	37
24	·201 0779	·205 2705	·871 620	·979 5752	·205 3502	·209 8218	·765 949	·978 6886	36
25	0·201 1492	0·205 3463	4·869 822	0·979 5606	0·205 4214	0·209 8977	4·764 225	0·978 6736	35
26	·201 2204	·205 4221	·868 025	·979 5460	·205 4925	·209 9737	·762 502	·978 6587	34
27	·201 2916	·205 4979	·866 230	·979 5314	·205 5637	·210 0496	·760 781	·978 6437	33
28	·201 3629	·205 5737	·864 436	·979 5167	·205 6349	·210 1255	·759 060	·978 6288	32
29	·201 4341	·205 6495	·862 643	·979 5021	·205 7060	·210 2014	·757 341	·978 6138	31
30	0·201 5053	0·205 7253	4·860 851	0·979 4874	0·205 7772	0·210 2774	4·755 623	0·978 5989	30
31	·201 5766	·205 8011	·859 061	·979 4728	·205 8484	·210 3533	·753 906	·978 5839	29
32	·201 6478	·205 8769	·857 272	·979 4581	·205 9195	·210 4293	·752 191	·978 5689	28
33	·201 7190	·205 9527	·855 484	·979 4434	·205 9907	·210 5052	·750 476	·978 5539	27
34	·201 7902	·206 0285	·853 698	·979 4288	·206 0619	·210 5812	·748 763	·978 5390	26
35	0·201 8615	0·206 1043	4·851 912	0·979 4141	0·206 1330	0·210 6571	4·747 051	0·978 5240	25
36	·201 9327	·206 1801	·850 128	·979 3994	·206 2042	·210 7331	·745 340	·978 5090	24
37	·202 0039	·206 2559	·848 345	·979 3847	·206 2753	·210 8090	·743 630	·978 4940	23
38	·202 0751	·206 3318	·846 564	·979 3700	·206 3465	·210 8850	·741 922	·978 4790	22
39	·202 1464	·206 4076	·844 784	·979 3553	·206 4177	·210 9609	·740 214	·978 4640	21
40	0·202 2176	0·206 4834	4·843 005	0·979 3406	0·206 4888	0·211 0369	4·738 508	0·978 4490	20
41	·202 2888	·206 5592	·841 227	·979 3259	·206 5600	·211 1128	·736 803	·978 4339	19
42	·202 3600	·206 6350	·839 450	·979 3112	·206 6311	·211 1888	·735 100	·978 4189	18
43	·202 4312	·206 7109	·837 675	·979 2965	·206 7023	·211 2648	·733 397	·978 4039	17
44	·202 5024	·206 7867	·835 901	·979 2818	·206 7734	·211 3407	·731 695	·978 3889	16
45	0·202 5737	0·206 8625	4·834 128	0·979 2670	0·206 8446	0·211 4167	4·729 995	0·978 3738	15
46	·202 6449	·206 9384	·832 357	·979 2523	·206 9157	·211 4927	·728 296	·978 3588	14
47	·202 7161	·207 0142	·830 586	·979 2376	·206 9869	·211 5687	·726 598	·978 3437	13
48	·202 7873	·207 0900	·828 817	·979 2228	·207 0580	·211 6446	·724 901	·978 3287	12
49	·202 8585	·207 1659	·827 050	·979 2081	·207 1292	·211 7206	·723 206	·978 3136	11
50	0·202 9297	0·207 2417	4·825 283	0·979 1933	0·207 2003	0·211 7966	4·721 511	0·978 2985	10
51	·203 0009	·207 3176	·823 518	·979 1785	·207 2715	·211 8726	·719 818	·978 2835	09
52	·203 0721	·207 3934	·821 754	·979 1638	·207 3426	·211 9486	·718 126	·978 2684	08
53	·203 1433	·207 4693	·819 991	·979 1490	·207 4137	·212 0246	·716 435	·978 2533	07
54	·203 2145	·207 5451	·818 229	·979 1342	·207 4849	·212 1006	·714 745	·978 2382	06
55	0·203 2857	0·207 6210	4·816 469	0·979 1195	0·207 5560	0·212 1766	4·713 056	0·978 2231	05
56	·203 3569	·207 6968	·814 710	·979 1047	·207 6272	·212 2525	·711 369	·978 2080	04
57	·203 4282	·207 7727	·812 952	·979 0899	·207 6983	·212 3285	·709 682	·978 1929	03
58	·203 4994	·207 8486	·811 195	·979 0751	·207 7694	·212 4046	·707 997	·978 1778	02
59	·203 5706	·207 9244	·809 440	·979 0603	·207 8406	·212 4806	·706 313	·978 1627	01
60	0·203 6418	0·208 0003	4·807 685	0·979 0455	0·207 9117	0·212 5566	4·704 630	0·978 1476	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	712–713	759–757	1755–1829	148–145	711–712	761–758	1683–1753	151–148	d

5^h 13^m | 5^h 12^m

$0^{h}\ 48^{m}$ $0^{h}\ 49^{m}$

d	712–710	760–762	1682–1616	151–155	711–710	761–763	1615–1552	154–158	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·207 9117	0·212 5566	4·704 630	0·978 1476	0·212 1777	0·217 1213	4·605 721	0·977 2311	60
01	·207 9828	·212 6326	·702 948	·978 1325	·212 2487	·217 1974	·604 106	·977 2157	59
02	·208 0540	·212 7086	·701 268	·978 1174	·212 3198	·217 2736	·602 492	·977 2002	58
03	·208 1251	·212 7846	·699 588	·978 1022	·212 3909	·217 3497	·600 880	·977 1848	57
04	·208 1962	·212 8606	·697 910	·978 0871	·212 4619	·217 4259	·599 268	·977 1693	56
05	0·208 2673	0·212 9366	4·696 233	0·978 0719	0·212 5330	0·217 5021	4·597 657	0·977 1539	55
06	·208 3385	·213 0126	·694 557	·978 0568	·212 6040	·217 5782	·596 048	·977 1384	54
07	·208 4096	·213 0887	·692 882	·978 0416	·212 6751	·217 6544	·594 440	·977 1230	53
08	·208 4807	·213 1647	·691 208	·978 0265	·212 7462	·217 7306	·592 832	·977 1075	52
09	·208 5518	·213 2407	·689 536	·978 0113	·212 8172	·217 8067	·591 226	·977 0920	51
10	0·208 6230	0·213 3168	4·687 864	0·977 9961	0·212 8883	0·217 8829	4·589 621	0·977 0765	50
11	·208 6941	·213 3928	·686 194	·977 9810	·212 9593	·217 9591	·588 017	·977 0611	49
12	·208 7652	·213 4688	·684 525	·977 9658	·213 0304	·218 0353	·586 414	·977 0456	48
13	·208 8363	·213 5449	·682 857	·977 9506	·213 1014	·218 1114	·584 812	·977 0301	47
14	·208 9074	·213 6209	·681 190	·977 9354	·213 1725	·218 1876	·583 211	·977 0146	46
15	0·208 9786	0·213 6969	4·679 524	0·977 9202	0·213 2435	0·218 2638	4·581 612	0·976 9991	45
16	·209 0497	·213 7730	·677 860	·977 9050	·213 3146	·218 3400	·580 013	·976 9836	44
17	·209 1208	·213 8490	·676 196	·977 8898	·213 3856	·218 4162	·578 415	·976 9680	43
18	·209 1919	·213 9251	·674 534	·977 8746	·213 4567	·218 4924	·576 819	·976 9525	42
19	·209 2630	·214 0011	·672 872	·977 8594	·213 5277	·218 5686	·575 223	·976 9370	41
20	0·209 3341	0·214 0772	4·671 212	0·977 8442	0·213 5988	0·218 6448	4·573 629	0·976 9215	40
21	·209 4052	·214 1532	·669 553	·977 8289	·213 6698	·218 7210	·572 035	·976 9059	39
22	·209 4763	·214 2293	·667 896	·977 8137	·213 7409	·218 7972	·570 443	·976 8904	38
23	·209 5475	·214 3054	·666 239	·977 7985	·213 8119	·218 8734	·568 852	·976 8748	37
24	·209 6186	·214 3814	·664 583	·977 7832	·213 8829	·218 9496	·567 261	·976 8593	36
25	0·209 6897	0·214 4575	4·662 929	0·977 7680	0·213 9540	0·219 0258	4·565 672	0·976 8437	35
26	·209 7608	·214 5336	·661 275	·977 7527	·214 0250	·219 1020	·564 084	·976 8282	34
27	·209 8319	·214 6096	·659 623	·977 7375	·214 0961	·219 1782	·562 497	·976 8126	33
28	·209 9030	·214 6857	·657 972	·977 7222	·214 1671	·219 2544	·560 911	·976 7970	32
29	·209 9741	·214 7618	·656 322	·977 7070	·214 2381	·219 3307	·559 326	·976 7815	31
30	0·210 0452	0·214 8379	4·654 673	0·977 6917	0·214 3092	0·219 4069	4·557 742	0·976 7659	30
31	·210 1163	·214 9139	·653 025	·977 6764	·214 3802	·219 4831	·556 159	·976 7503	29
32	·210 1874	·214 9900	·651 379	·977 6611	·214 4512	·219 5593	·554 578	·976 7347	28
33	·210 2585	·215 0661	·649 733	·977 6458	·214 5222	·219 6356	·552 997	·976 7191	27
34	·210 3296	·215 1422	·648 089	·977 6305	·214 5933	·219 7118	·551 417	·976 7035	26
35	0·210 4007	0·215 2183	4·646 446	0·977 6152	0·214 6643	0·219 7880	4·549 838	0·976 6879	25
36	·210 4718	·215 2944	·644 803	·977 5999	·214 7353	·219 8643	·548 261	·976 6723	24
37	·210 5429	·215 3705	·643 162	·977 5846	·214 8064	·219 9405	·546 684	·976 6567	23
38	·210 6139	·215 4466	·641 522	·977 5693	·214 8774	·220 0167	·545 109	·976 6410	22
39	·210 6850	·215 5227	·639 883	·977 5540	·214 9484	·220 0930	·543 534	·976 6254	21
40	0·210 7561	0·215 5988	4·638 246	0·977 5387	0·215 0194	0·220 1692	4·541 961	0·976 6098	20
41	·210 8272	·215 6749	·636 609	·977 5233	·215 0904	·220 2455	·540 388	·976 5941	19
42	·210 8983	·215 7510	·634 973	·977 5080	·215 1615	·220 3217	·538 817	·976 5785	18
43	·210 9694	·215 8271	·633 339	·977 4927	·215 2325	·220 3980	·537 247	·976 5628	17
44	·211 0405	·215 9032	·631 706	·977 4773	·215 3035	·220 4742	·535 677	·976 5472	16
45	0·211 1116	0·215 9793	4·630 073	0·977 4620	0·215 3745	0·220 5505	4·534 109	0·976 5315	15
46	·211 1826	·216 0554	·628 442	·977 4466	·215 4455	·220 6268	·532 542	·976 5159	14
47	·211 2537	·216 1315	·626 812	·977 4313	·215 5165	·220 7030	·530 976	·976 5002	13
48	·211 3248	·216 2077	·625 183	·977 4159	·215 5876	·220 7793	·529 410	·976 4845	12
49	·211 3959	·216 2838	·623 555	·977 4005	·215 6586	·220 8556	·527 846	·976 4688	11
50	0·211 4670	0·216 3599	4·621 929	0·977 3851	0·215 7296	0·220 9318	4·526 283	0·976 4531	10
51	·211 5380	·216 4360	·620 303	·977 3698	·215 8006	·221 0081	·524 721	·976 4375	09
52	·211 6091	·216 5122	·618 678	·977 3544	·215 8716	·221 0844	·523 160	·976 4218	08
53	·211 6802	·216 5883	·617 055	·977 3390	·215 9426	·221 1606	·521 600	·976 4061	07
54	·211 7513	·216 6644	·615 432	·977 3236	·216 0136	·221 2369	·520 041	·976 3904	06
55	0·211 8223	0·216 7406	4·613 811	0·977 3082	0·216 0846	0·221 3132	4·518 483	0·976 3746	05
56	·211 8934	·216 8167	·612 191	·977 2928	·216 1556	·221 3895	·516 926	·976 3589	04
57	·211 9645	·216 8928	·610 572	·977 2774	·216 2266	·221 4658	·515 370	·976 3432	03
58	·212 0355	·216 9690	·608 954	·977 2620	·216 2976	·221 5421	·513 815	·976 3275	02
59	·212 1066	·217 0451	·607 337	·977 2465	·216 3686	·221 6184	·512 261	·976 3117	01
60	0·212 1777	0·217 1213	4·605 721	0·977 2311	0·216 4396	0·221 6947	4·510 709	0·976 2960	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	710–712	762–760	1616–1682	155–151	710–711	763–761	1552–1615	158–154	d

$5^{h}\ 11^{m}$ $5^{h}\ 10^{m}$

0^h 50^m 0^h 51^m

d	710–709	763–765	1552–1494	157–161	710–708	764–766	1492–1437	160–164	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·216 4396	0·221 6947	4·510 709	0·976 2960	0·220 6974	0·226 2769	4·419 364	0·975 3423	60
01	·216 5106	·221 7710	·509 157	·976 2803	·220 7684	·226 3533	·417 872	·975 3263	59
02	·216 5816	·221 8473	·507 606	·976 2645	·220 8393	·226 4298	·416 380	·975 3102	58
03	·216 6526	·221 9236	·506 056	·976 2488	·220 9102	·226 5062	·414 889	·975 2941	57
04	·216 7236	·221 9999	·504 507	·976 2330	·220 9811	·226 5827	·413 400	·975 2781	56
05	0·216 7946	0·222 0762	4·502 959	0·976 2172	0·221 0521	0·226 6592	4·411 911	0·975 2620	55
06	·216 8656	·222 1525	·501 413	·976 2015	·221 1230	·226 7356	·410 423	·975 2459	54
07	·216 9366	·222 2288	·499 867	·976 1857	·221 1939	·226 8121	·408 936	·975 2298	53
08	·217 0076	·222 3051	·498 322	·976 1699	·221 2648	·226 8885	·407 450	·975 2138	52
09	·217 0786	·222 3814	·496 778	·976 1541	·221 3357	·226 9650	·405 965	·975 1977	51
10	0·217 1495	0·222 4577	4·495 236	0·976 1383	0·221 4067	0·227 0415	4·404 482	0·975 1816	50
11	·217 2205	·222 5341	·493 694	·976 1226	·221 4776	·227 1180	·402 999	·975 1655	49
12	·217 2915	·222 6104	·492 153	·976 1068	·221 5485	·227 1944	·401 516	·975 1494	48
13	·217 3625	·222 6867	·490 614	·976 0910	·221 6194	·227 2709	·400 035	·975 1332	47
14	·217 4335	·222 7631	·489 075	·976 0751	·221 6903	·227 3474	·398 555	·975 1171	46
15	0·217 5045	0·222 8394	4·487 537	0·976 0593	0·221 7612	0·227 4239	4·397 076	0·975 1010	45
16	·217 5754	·222 9157	·486 000	·976 0435	·221 8321	·227 5003	·395 598	·975 0849	44
17	·217 6464	·222 9921	·484 465	·976 0277	·221 9031	·227 5768	·394 120	·975 0687	43
18	·217 7174	·223 0684	·482 930	·976 0119	·221 9740	·227 6533	·392 644	·975 0526	42
19	·217 7884	·223 1447	·481 396	·975 9960	·222 0449	·227 7298	·391 168	·975 0364	41
20	0·217 8593	0·223 2211	4·479 864	0·975 9802	0·222 1158	0·227 8063	4·389 694	0·975 0203	40
21	·217 9303	·223 2974	·478 332	·975 9643	·222 1867	·227 8828	·388 220	·975 0041	39
22	·218 0013	·223 3738	·476 801	·975 9485	·222 2576	·227 9593	·386 748	·974 9880	38
23	·218 0723	·223 4501	·475 272	·975 9326	·222 3285	·228 0358	·385 276	·974 9718	37
24	·218 1432	·223 5265	·473 743	·975 9168	·222 3994	·228 1123	·383 805	·974 9556	36
25	0·218 2142	0·223 6028	4·472 215	0·975 9009	0·222 4703	0·228 1888	4·382 336	0·974 9395	35
26	·218 2852	·223 6792	·470 688	·975 8850	·222 5412	·228 2653	·380 867	·974 9233	34
27	·218 3561	·223 7556	·469 163	·975 8691	·222 6121	·228 3418	·379 399	·974 9071	33
28	·218 4271	·223 8319	·467 638	·975 8533	·222 6830	·228 4184	·377 932	·974 8909	32
29	·218 4981	·223 9083	·466 114	·975 8374	·222 7539	·228 4949	·376 466	·974 8747	31
30	0·218 5690	0·223 9847	4·464 591	0·975 8215	0·222 8248	0·228 5714	4·375 001	0·974 8585	30
31	·218 6400	·224 0610	·463 070	·975 8056	·222 8957	·228 6479	·373 536	·974 8423	29
32	·218 7110	·224 1374	·461 549	·975 7897	·222 9666	·228 7244	·372 073	·974 8261	28
33	·218 7819	·224 2138	·460 029	·975 7738	·223 0375	·228 8010	·370 611	·974 8099	27
34	·218 8529	·224 2902	·458 510	·975 7579	·223 1083	·228 8775	·369 149	·974 7937	26
35	0·218 9238	0·224 3665	4·456 992	0·975 7419	0·223 1792	0·228 9540	4·367 689	0·974 7774	25
36	·218 9948	·224 4429	·455 476	·975 7260	·223 2501	·229 0306	·366 229	·974 7612	24
37	·219 0658	·224 5193	·453 960	·975 7101	·223 3210	·229 1071	·364 771	·974 7450	23
38	·219 1367	·224 5957	·452 445	·975 6942	·223 3919	·229 1837	·363 313	·974 7287	22
39	·219 2077	·224 6721	·450 931	·975 6782	·223 4628	·229 2602	·361 856	·974 7125	21
40	0·219 2786	0·224 7485	4·449 418	0·975 6623	0·223 5337	0·229 3367	4·360 400	0·974 6962	20
41	·219 3496	·224 8249	·447 906	·975 6463	·223 6045	·229 4133	·358 945	·974 6800	19
42	·219 4205	·224 9013	·446 395	·975 6304	·223 6754	·229 4898	·357 491	·974 6637	18
43	·219 4915	·224 9777	·444 885	·975 6144	·223 7463	·229 5664	·356 038	·974 6474	17
44	·219 5624	·225 0541	·443 376	·975 5985	·223 8172	·229 6429	·354 586	·974 6311	16
45	0·219 6334	0·225 1305	4·441 868	0·975 5825	0·223 8880	0·229 7195	4·353 135	0·974 6149	15
46	·219 7043	·225 2069	·440 361	·975 5665	·223 9589	·229 7961	·351 685	·974 5986	14
47	·219 7753	·225 2833	·438 855	·975 5505	·224 0298	·229 8726	·350 235	·974 5823	13
48	·219 8462	·225 3597	·437 350	·975 5345	·224 1007	·229 9492	·348 787	·974 5660	12
49	·219 9171	·225 4361	·435 846	·975 5186	·224 1715	·230 0258	·347 339	·974 5497	11
50	0·219 9881	0·225 5126	4·434 343	0·975 5026	0·224 2424	0·230 1023	4·345 892	0·974 5334	10
51	·220 0590	·225 5890	·432 840	·975 4866	·224 3133	·230 1789	·344 447	·974 5171	09
52	·220 1300	·225 6654	·431 339	·975 4706	·224 3842	·230 2555	·343 002	·974 5008	08
53	·220 2009	·225 7418	·429 839	·975 4545	·224 4550	·230 3321	·341 558	·974 4845	07
54	·220 2718	·225 8183	·428 340	·975 4385	·224 5259	·230 4086	·340 115	·974 4681	06
55	0·220 3428	0·225 8947	4·426 841	0·975 4225	0·224 5967	0·230 4852	4·338 673	0·974 4518	05
56	·220 4137	·225 9711	·425 344	·975 4065	·224 6676	·230 5618	·337 232	·974 4355	04
57	·220 4846	·226 0476	·423 848	·975 3904	·224 7385	·230 6384	·335 791	·974 4191	03
58	·220 5556	·226 1240	·422 352	·975 3744	·224 8093	·230 7150	·334 352	·974 4028	02
59	·220 6265	·226 2005	·420 858	·975 3584	·224 8802	·230 7916	·332 913	·974 3864	01
60	0·220 6974	0·226 2769	4·419 364	0·975 3423	0·224 9511	0·230 8682	4·331 476	0·974 3701	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	709–710	765–763	1494–1552	161–157	708–710	766–764	1437–1492	164–160	d

5^h 09^m 5^h 08^m

0^{h} 52^{m} — 0^{h} 53^{m}

d	709–707	766–768	1437–1385	163–167	708–707	767–770	1384–1335	166–170	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·224 9511	0·230 8682	4·331 476	0·974 3701	0·229 2004	0·235 4687	4·246 848	0·973 3793	60
01	·225 0219	·230 9448	·330 039	·974 3537	·229 2712	·235 5455	·245 464	·973 3626	59
02	·225 0928	·231 0214	·328 603	·974 3373	·229 3420	·235 6223	·244 081	·973 3459	58
03	·225 1636	·231 0980	·327 169	·974 3210	·229 4127	·235 6990	·242 699	·973 3292	57
04	·225 2345	·231 1746	·325 735	·974 3046	·229 4835	·235 7758	·241 318	·973 3125	56
05	0·225 3053	0·231 2512	4·324 302	0·974 2882	0·229 5543	0·235 8525	4·239 937	0·973 2959	55
06	·225 3762	·231 3278	·322 869	·974 2718	·229 6251	·235 9293	·238 558	·973 2792	54
07	·225 4470	·231 4044	·321 438	·974 2554	·229 6959	·236 0061	·237 179	·973 2625	53
08	·225 5179	·231 4811	·320 008	·974 2390	·229 7666	·236 0829	·235 801	·973 2458	52
09	·225 5887	·231 5577	·318 578	·974 2226	·229 8374	·236 1596	·234 424	·973 2290	51
10	0·225 6596	0·231 6343	4·317 150	0·974 2062	0·229 9082	0·236 2364	4·233 048	0·973 2123	50
11	·225 7304	·231 7109	·315 722	·974 1898	·229 9790	·236 3132	·231 672	·973 1956	49
12	·225 8013	·231 7876	·314 295	·974 1734	·230 0497	·236 3900	·230 298	·973 1789	48
13	·225 8721	·231 8642	·312 870	·974 1570	·230 1205	·236 4668	·228 924	·973 1621	47
14	·225 9430	·231 9408	·311 445	·974 1405	·230 1913	·236 5436	·227 551	·973 1454	46
15	0·226 0138	0·232 0175	4·310 021	0·974 1241	0·230 2620	0·236 6204	4·226 179	0·973 1287	45
16	·226 0846	·232 0941	·308 597	·974 1077	·230 3328	·236 6971	·224 808	·973 1119	44
17	·226 1555	·232 1707	·307 175	·974 0912	·230 4036	·236 7739	·223 438	·973 0952	43
18	·226 2263	·232 2474	·305 754	·974 0748	·230 4743	·236 8507	·222 068	·973 0784	42
19	·226 2971	·232 3240	·304 333	·974 0583	·230 5451	·236 9275	·220 700	·973 0616	41
20	0·226 3680	0·232 4007	4·302 914	0·974 0419	0·230 6159	0·237 0044	4·219 332	0·973 0449	40
21	·226 4388	·232 4773	·301 495	·974 0254	·230 6866	·237 0812	·217 965	·973 0281	39
22	·226 5096	·232 5540	·300 077	·974 0089	·230 7574	·237 1580	·216 599	·973 0113	38
23	·226 5805	·232 6306	·298 660	·973 9924	·230 8282	·237 2348	·215 233	·972 9945	37
24	·226 6513	·232 7073	·297 244	·973 9760	·230 8989	·237 3116	·213 869	·972 9777	36
25	0·226 7221	0·232 7840	4·295 829	0·973 9595	0·230 9697	0·237 3884	4·212 505	0·972 9610	35
26	·226 7930	·232 8606	·294 414	·973 9430	·231 0404	·237 4652	·211 143	·972 9442	34
27	·226 8638	·232 9373	·293 001	·973 9265	·231 1112	·237 5421	·209 781	·972 9273	33
28	·226 9346	·233 0140	·291 589	·973 9100	·231 1819	·237 6189	·208 420	·972 9105	32
29	·227 0054	·233 0906	·290 177	·973 8935	·231 2527	·237 6957	·207 059	·972 8937	31
30	0·227 0763	0·233 1673	4·288 766	0·973 8770	0·231 3234	0·237 7726	4·205 700	0·972 8769	30
31	·227 1471	·233 2440	·287 356	·973 8605	·231 3942	·237 8494	·204 341	·972 8601	29
32	·227 2179	·233 3207	·285 947	·973 8439	·231 4649	·237 9262	·202 983	·972 8432	28
33	·227 2887	·233 3973	·284 539	·973 8274	·231 5357	·238 0031	·201 627	·972 8264	27
34	·227 3595	·233 4740	·283 132	·973 8109	·231 6064	·238 0799	·200 270	·972 8096	26
35	0·227 4304	0·233 5507	4·281 725	0·973 7943	0·231 6772	0·238 1568	4·198 915	0·972 7927	25
36	·227 5012	·233 6274	·280 320	·973 7778	·231 7479	·238 2336	·197 561	·972 7759	24
37	·227 5720	·233 7041	·278 915	·973 7613	·231 8186	·238 3105	·196 207	·972 7590	23
38	·227 6428	·233 7808	·277 511	·973 7447	·231 8894	·238 3873	·194 854	·972 7422	22
39	·227 7136	·233 8575	·276 109	·973 7281	·231 9601	·238 4642	·193 502	·972 7253	21
40	0·227 7844	0·233 9342	4·274 707	0·973 7116	0·232 0309	0·238 5410	4·192 151	0·972 7084	20
41	·227 8552	·234 0109	·273 305	·973 6950	·232 1016	·238 6179	·190 801	·972 6915	19
42	·227 9260	·234 0876	·271 905	·973 6784	·232 1723	·238 6947	·189 451	·972 6747	18
43	·227 9969	·234 1643	·270 506	·973 6619	·232 2431	·238 7716	·188 103	·972 6578	17
44	·228 0677	·234 2410	·269 107	·973 6453	·232 3138	·238 8485	·186 755	·972 6409	16
45	0·228 1385	0·234 3177	4·267 710	0·973 6287	0·232 3845	0·238 9254	4·185 408	0·972 6240	15
46	·228 2093	·234 3944	·266 313	·973 6121	·232 4553	·239 0022	·184 061	·972 6071	14
47	·228 2801	·234 4712	·264 917	·973 5955	·232 5260	·239 0791	·182 716	·972 5902	13
48	·228 3509	·234 5479	·263 522	·973 5789	·232 5967	·239 1560	·181 371	·972 5733	12
49	·228 4217	·234 6246	·262 128	·973 5623	·232 6674	·239 2329	·180 028	·972 5564	11
50	0·228 4925	0·234 7013	4·260 734	0·973 5457	0·232 7382	0·239 3098	4·178 685	0·972 5394	10
51	·228 5633	·234 7781	·259 342	·973 5291	·232 8089	·239 3866	·177 342	·972 5225	09
52	·228 6341	·234 8548	·257 950	·973 5124	·232 8796	·239 4635	·176 001	·972 5056	08
53	·228 7049	·234 9315	·256 559	·973 4958	·232 9503	·239 5404	·174 661	·972 4886	07
54	·228 7757	·235 0083	·255 169	·973 4792	·233 0211	·239 6173	·173 321	·972 4717	06
55	0·228 8464	0·235 0850	4·253 780	0·973 4625	0·233 0918	0·239 6942	4·171 982	0·972 4547	05
56	·228 9172	·235 1617	·252 392	·973 4459	·233 1625	·239 7711	·170 644	·972 4378	04
57	·228 9880	·235 2385	·251 005	·973 4292	·233 2332	·239 8480	·169 307	·972 4208	03
58	·229 0588	·235 3152	·249 619	·973 4126	·233 3039	·239 9249	·167 970	·972 4039	02
59	·229 1296	·235 3920	·248 233	·973 3959	·233 3747	·240 0018	·166 635	·972 3869	01
60	0·229 2004	0·235 4687	4·246 848	0·973 3793	0·233 4454	0·240 0788	4·165 300	0·972 3699	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	707–709	768–766	1385–1437	167–163	707–708	770–767	1335–1384	170–166	d

5^{h} 07^{m} — 5^{h} 06^{m}

	$0^{h}\ 54^{m}$				$0^{h}\ 55^{m}$				
d	707–706	769–771	1334–1287	169–173	707–705	770–773	1287–1243	173–176	d
	sin	tan	cot	cos	sin	tan	cot	cos	
s									
00	0·233 4454	0·240 0788	4·165 300	0·972 3699	0·237 6859	0·244 6984	4·086 663	0·971 3421	60
01	·233 5161	·240 1557	·163 966	·972 3529	·237 7565	·244 7755	·085 376	·971 3248	59
02	·233 5868	·240 2326	·162 633	·972 3360	·237 8272	·244 8526	·084 090	·971 3075	58
03	·233 6575	·240 3095	·161 300	·972 3190	·237 8978	·244 9297	·082 804	·971 2902	57
04	·233 7282	·240 3864	·159 969	·972 3020	·237 9684	·245 0068	·081 520	·971 2729	56
05	0·233 7989	0·240 4634	4·158 638	0·972 2850	0·238 0391	0·245 0839	4·080 236	0·971 2556	55
06	·233 8696	·240 5403	·157 308	·972 2680	·238 1097	·245 1610	·078 953	·971 2383	54
07	·233 9403	·240 6172	·155 979	·972 2510	·238 1803	·245 2380	·077 671	·971 2209	53
08	·234 0110	·240 6942	·154 650	·972 2339	·238 2510	·245 3151	·076 389	·971 2036	52
09	·234 0817	·240 7711	·153 323	·972 2169	·238 3216	·245 3922	·075 108	·971 1863	51
10	0·234 1524	0·240 8480	4·151 996	0·972 1999	0·238 3922	0·245 4693	4·073 828	0·971 1690	50
11	·234 2231	·240 9250	·150 670	·972 1829	·238 4628	·245 5465	·072 549	·971 1516	49
12	·234 2938	·241 0019	·149 345	·972 1658	·238 5335	·245 6236	·071 271	·971 1343	48
13	·234 3645	·241 0789	·148 020	·972 1488	·238 6041	·245 7007	·069 993	·971 1169	47
14	·234 4352	·241 1558	·146 697	·972 1317	·238 6747	·245 7778	·068 716	·971 0996	46
15	0·234 5059	0·241 2328	4·145 374	0·972 1147	0·238 7453	0·245 8549	4·067 440	0·971 0822	45
16	·234 5766	·241 3097	·144 052	·972 0976	·238 8159	·245 9320	·066 164	·971 0649	44
17	·234 6473	·241 3867	·142 731	·972 0806	·238 8866	·246 0091	·064 890	·971 0475	43
18	·234 7180	·241 4636	·141 410	·972 0635	·238 9572	·246 0863	·063 616	·971 0301	42
19	·234 7887	·241 5406	·140 091	·972 0464	·239 0278	·246 1634	·062 342	·971 0127	41
20	0·234 8594	0·241 6176	4·138 772	0·972 0294	0·239 0984	0·246 2405	4·061 070	0·970 9953	40
21	·234 9301	·241 6945	·137 454	·972 0123	·239 1690	·246 3177	·059 798	·970 9780	39
22	·235 0007	·241 7715	·136 137	·971 9952	·239 2396	·246 3948	·058 527	·970 9606	38
23	·235 0714	·241 8485	·134 820	·971 9781	·239 3102	·246 4719	·057 257	·970 9432	37
24	·235 1421	·241 9255	·133 505	·971 9610	·239 3808	·246 5491	·055 988	·970 9258	36
25	0·235 2128	0·242 0024	4·132 190	0·971 9439	0·239 4514	0·246 6262	4·054 719	0·970 9083	35
26	·235 2835	·242 0794	·130 876	·971 9268	·239 5221	·246 7034	·053 451	·970 8909	34
27	·235 3542	·242 1564	·129 562	·971 9097	·239 5927	·246 7805	·052 184	·970 8735	33
28	·235 4248	·242 2334	·128 250	·971 8926	·239 6633	·246 8577	·050 917	·970 8561	32
29	·235 4955	·242 3104	·126 938	·971 8754	·239 7339	·246 9348	·049 652	·970 8386	31
30	0·235 5662	0·242 3874	4·125 627	0·971 8583	0·239 8045	0·247 0120	4·048 387	0·970 8212	30
31	·235 6369	·242 4644	·124 317	·971 8412	·239 8751	·247 0891	·047 122	·970 8038	29
32	·235 7075	·242 5414	·123 008	·971 8240	·239 9457	·247 1663	·045 859	·970 7863	28
33	·235 7782	·242 6184	·121 699	·971 8069	·240 0163	·247 2435	·044 596	·970 7689	27
34	·235 8489	·242 6954	·120 392	·971 7897	·240 0869	·247 3206	·043 334	·970 7514	26
35	0·235 9196	0·242 7724	4·119 085	0·971 7726	0·240 1574	0·247 3978	4·042 073	0·970 7339	25
36	·235 9902	·242 8494	·117 778	·971 7554	·240 2280	·247 4750	·040 813	·970 7165	24
37	·236 0609	·242 9264	·116 473	·971 7383	·240 2986	·247 5522	·039 553	·970 6990	23
38	·236 1316	·243 0034	·115 168	·971 7211	·240 3692	·247 6293	·038 294	·970 6815	22
39	·236 2022	·243 0804	·113 865	·971 7039	·240 4398	·247 7065	·037 035	·970 6640	21
40	0·236 2729	0·243 1575	4·112 561	0·971 6867	0·240 5104	0·247 7837	4·035 778	0·970 6466	20
41	·236 3435	·243 2345	·111 259	·971 6696	·240 5810	·247 8609	·034 521	·970 6291	19
42	·236 4142	·243 3115	·109 958	·971 6524	·240 6516	·247 9381	·033 265	·970 6116	18
43	·236 4849	·243 3885	·108 657	·971 6352	·240 7222	·248 0153	·032 010	·970 5941	17
44	·236 5555	·243 4656	·107 357	·971 6180	·240 7927	·248 0925	·030 755	·970 5766	16
45	0·236 6262	0·243 5426	4·106 058	0·971 6008	0·240 8633	0·248 1697	4·029 501	0·970 5590	15
46	·236 6968	·243 6196	·104 759	·971 5836	·240 9339	·248 2469	·028 248	·970 5415	14
47	·236 7675	·243 6967	·103 462	·971 5663	·241 0045	·248 3241	·026 996	·970 5240	13
48	·236 8381	·243 7737	·102 165	·971 5491	·241 0751	·248 4013	·025 744	·970 5065	12
49	·236 9088	·243 8508	·100 869	·971 5319	·241 1456	·248 4785	·024 493	·970 4889	11
50	0·236 9794	0·243 9278	4·099 573	0·971 5147	0·241 2162	0·248 5557	4·023 243	0·970 4714	10
51	·237 0501	·244 0049	·098 279	·971 4974	·241 2868	·248 6329	·021 993	·970 4539	09
52	·237 1207	·244 0819	·096 985	·971 4802	·241 3574	·248 7102	·020 745	·970 4363	08
53	·237 1914	·244 1590	·095 692	·971 4629	·241 4279	·248 7874	·019 497	·970 4188	07
54	·237 2620	·244 2360	·094 400	·971 4457	·241 4985	·248 8646	·018 249	·970 4012	06
55	0·237 3327	0·244 3131	4·093 108	0·971 4284	0·241 5691	0·248 9418	4·017 003	0·970 3836	05
56	·237 4033	·244 3902	·091 818	·971 4112	·241 6396	·249 0191	·015 757	·970 3661	04
57	·237 4740	·244 4672	·090 528	·971 3939	·241 7102	·249 0963	·014 512	·970 3485	03
58	·237 5446	·244 5443	·089 239	·971 3766	·241 7808	·249 1735	·013 267	·970 3309	02
59	·237 6153	·244 6214	·087 950	·971 3594	·241 8513	·249 2508	·012 024	·970 3133	01
60	0·237 6859	0·244 6984	4·086 663	0·971 3421	0·241 9219	0·249 3280	4·010 781	0·970 2957	00
									s
	cos	cot	tan	sin	cos	cot	tan	sin	
d	706–707	771–769	1287–1334	173–169	705–707	773–770	1243–1287	176–173	d
	$5^{h}\ 05^{m}$				$5^{h}\ 04^{m}$				

	$0^h\ 56^m$				$0^h\ 57^m$				
d	706–704	772–774	1242–1201	176–179	705–704	774–776	1200–1160	179–182	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·241 9219	0·249 3280	4·010 781	0·970 2957	0·246 1533	0·253 9676	3·937 509	0·969 2309	60
01	·241 9925	·249 4052	·009 539	·970 2781	·246 2238	·254 0451	·936 310	·969 2130	59
02	·242 0630	·249 4825	·008 297	·970 2605	·246 2943	·254 1225	·935 110	·969 1951	58
03	·242 1336	·249 5597	·007 057	·970 2429	·246 3647	·254 1999	·933 912	·969 1772	57
04	·242 2041	·249 6370	·005 817	·970 2253	·246 4352	·254 2773	·932 714	·969 1593	56
05	0·242 2747	0·249 7143	4·004 577	0·970 2077	0·246 5057	0·254 3547	3·931 517	0·969 1413	55
06	·242 3452	·249 7915	·003 339	·970 1901	·246 5762	·254 4322	·930 321	·969 1234	54
07	·242 4158	·249 8688	·002 101	·970 1724	·246 6467	·254 5096	·929 125	·969 1055	53
08	·242 4863	·249 9460	4·000 864	·970 1548	·246 7171	·254 5870	·927 930	·969 0875	52
09	·242 5569	·250 0233	3·999 627	·970 1372	·246 7876	·254 6645	·926 735	·969 0696	51
10	0·242 6275	0·250 1006	3·998 392	0·970 1195	0·246 8581	0·254 7419	3·925 542	0·969 0516	50
11	·242 6980	·250 1778	·997 157	·970 1019	·246 9285	·254 8194	·924 349	·969 0337	49
12	·242 7685	·250 2551	·995 922	·970 0842	·246 9990	·254 8968	·923 156	·969 0157	48
13	·242 8391	·250 3324	·994 689	·970 0666	·247 0695	·254 9743	·921 965	·968 9978	47
14	·242 9096	·250 4097	·993 456	·970 0489	·247 1399	·255 0517	·920 774	·968 9798	46
15	0·242 9802	0·250 4870	3·992 224	0·970 0313	0·247 2104	0·255 1292	3·919 583	0·968 9618	45
16	·243 0507	·250 5642	·990 992	·970 0136	·247 2809	·255 2066	·918 394	·968 9438	44
17	·243 1213	·250 6415	·989 762	·969 9959	·247 3513	·255 2841	·917 205	·968 9259	43
18	·243 1918	·250 7188	·988 532	·969 9782	·247 4218	·255 3615	·916 017	·968 9079	42
19	·243 2623	·250 7961	·987 302	·969 9605	·247 4923	·255 4390	·914 829	·968 8899	41
20	0·243 3329	0·250 8734	3·986 074	0·969 9428	0·247 5627	0·255 5165	3·913 642	0·968 8719	40
21	·243 4034	·250 9507	·984 846	·969 9251	·247 6332	·255 5939	·912 456	·968 8539	39
22	·243 4739	·251 0280	·983 619	·969 9074	·247 7036	·255 6714	·911 270	·968 8359	38
23	·243 5445	·251 1053	·982 393	·969 8897	·247 7741	·255 7489	·910 085	·968 8178	37
24	·243 6150	·251 1826	·981 167	·969 8720	·247 8445	·255 8264	·908 901	·968 7998	36
25	0·243 6855	0·251 2600	3·979 942	0·969 8543	0·247 9150	0·255 9039	3·907 718	0·968 7818	35
26	·243 7561	·251 3373	·978 718	·969 8366	·247 9854	·255 9813	·906 535	·968 7638	34
27	·243 8266	·251 4146	·977 494	·969 8188	·248 0559	·256 0588	·905 353	·968 7457	33
28	·243 8971	·251 4919	·976 271	·969 8011	·248 1263	·256 1363	·904 171	·968 7277	32
29	·243 9677	·251 5692	·975 049	·969 7834	·248 1968	·256 2138	·902 990	·968 7096	31
30	0·244 0382	0·251 6466	3·973 828	0·969 7656	0·248 2672	0·256 2913	3·901 810	0·968 6916	30
31	·244 1087	·251 7239	·972 607	·969 7479	·248 3377	·256 3688	·900 630	·968 6735	29
32	·244 1792	·251 8012	·971 387	·969 7301	·248 4081	·256 4463	·899 452	·968 6555	28
33	·244 2497	·251 8785	·970 167	·969 7124	·248 4786	·256 5238	·898 273	·968 6374	27
34	·244 3203	·251 9559	·968 949	·969 6946	·248 5490	·256 6013	·897 096	·968 6193	26
35	0·244 3908	0·252 0332	3·967 731	0·969 6768	0·248 6194	0·256 6788	3·895 919	0·968 6012	25
36	·244 4613	·252 1106	·966 514	·969 6591	·248 6899	·256 7564	·894 743	·968 5832	24
37	·244 5318	·252 1879	·965 297	·969 6413	·248 7603	·256 8339	·893 567	·968 5651	23
38	·244 6023	·252 2653	·964 081	·969 6235	·248 8308	·256 9114	·892 392	·968 5470	22
39	·244 6728	·252 3426	·962 866	·969 6057	·248 9012	·256 9889	·891 218	·968 5289	21
40	0·244 7433	0·252 4200	3·961 652	0·969 5879	0·248 9716	0·257 0664	3·890 045	0·968 5108	20
41	·244 8139	·252 4973	·960 438	·969 5701	·249 0421	·257 1440	·888 872	·968 4927	19
42	·244 8844	·252 5747	·959 225	·969 5523	·249 1125	·257 2215	·887 700	·968 4746	18
43	·244 9549	·252 6520	·958 013	·969 5345	·249 1829	·257 2990	·886 528	·968 4564	17
44	·245 0254	·252 7294	·956 801	·969 5167	·249 2533	·257 3766	·885 357	·968 4383	16
45	0·245 0959	0·252 8068	3·955 590	0·969 4988	0·249 3238	0·257 4541	3·884 187	0·968 4202	15
46	·245 1664	·252 8841	·954 380	·969 4810	·249 3942	·257 5317	·883 018	·968 4021	14
47	·245 2369	·252 9615	·953 170	·969 4632	·249 4646	·257 6092	·881 849	·968 3839	13
48	·245 3074	·253 0389	·951 962	·969 4453	·249 5350	·257 6868	·880 681	·968 3658	12
49	·245 3779	·253 1163	·950 753	·969 4275	·249 6055	·257 7643	·879 513	·968 3476	11
50	0·245 4484	0·253 1937	3·949 546	0·969 4097	0·249 6759	0·257 8419	3·878 346	0·968 3295	10
51	·245 5189	·253 2710	·948 339	·969 3918	·249 7463	·257 9194	·877 180	·968 3113	09
52	·245 5894	·253 3484	·947 133	·969 3740	·249 8167	·257 9970	·876 014	·968 2931	08
53	·245 6599	·253 4258	·945 928	·969 3561	·249 8871	·258 0746	·874 849	·968 2750	07
54	·245 7304	·253 5032	·944 723	·969 3382	·249 9575	·258 1521	·873 685	·968 2568	06
55	0·245 8009	0·253 5806	3·943 519	0·969 3203	0·250 0280	0·258 2297	3·872 521	0·968 2386	05
56	·245 8713	·253 6580	·942 316	·969 3025	·250 0984	·258 3073	·871 358	·968 2204	04
57	·245 9418	·253 7354	·941 113	·969 2846	·250 1688	·258 3848	·870 196	·968 2022	03
58	·246 0123	·253 8128	·939 911	·969 2667	·250 2392	·258 4624	·869 034	·968 1840	02
59	·246 0828	·253 8902	·938 710	·969 2488	·250 3096	·258 5400	·867 873	·968 1658	01
60	0·246 1533	0·253 9676	3·937 509	0·969 2309	0·250 3800	0·258 6176	3·866 713	0·968 1476	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	704–706	774–772	1201–1242	179–176	704–705	776–774	1160–1200	182–179	d
	$5^h\ 03^m$				$5^h\ 02^m$				

	$0^h\ 58^m$				$0^h\ 59^m$				
d	704–703	776–778	1160–1122	182–186	704–702	777–780	1121–1086	185–189	d
	sin	tan	cot	cos	sin	tan	cot	cos	
s									
00	0·250 3800	0·258 6176	3·866 713	0·968 1476	0·254 6019	0·263 2780	3·798 266	0·967 0459	60
01	·250 4504	·258 6952	·865 553	·968 1294	·254 6723	·263 3558	·797 145	·967 0274	59
02	·250 5208	·258 7728	·864 394	·968 1112	·254 7426	·263 4336	·796 024	·967 0089	58
03	·250 5912	·258 8504	·863 236	·968 0930	·254 8129	·263 5113	·794 903	·966 9904	57
04	·250 6616	·258 9280	·862 078	·968 0748	·254 8832	·263 5891	·793 784	·966 9718	56
05	0·250 7320	0·259 0056	3·860 921	0·968 0565	0·254 9536	0·263 6669	3·792 664	0·966 9533	55
06	·250 8024	·259 0832	·859 765	·968 0383	·255 0239	·263 7447	·791 546	·966 9348	54
07	·250 8728	·259 1608	·858 609	·968 0201	·255 0942	·263 8224	·790 428	·966 9162	53
08	·250 9432	·259 2384	·857 454	·968 0018	·255 1645	·263 9002	·789 311	·966 8977	52
09	·251 0136	·259 3160	·856 299	·967 9836	·255 2348	·263 9780	·788 194	·966 8791	51
10	0·251 0840	0·259 3936	3·855 145	0·967 9653	0·255 3051	0·264 0558	3·787 078	0·966 8605	50
11	·251 1544	·259 4712	·853 992	·967 9470	·255 3754	·264 1336	·785 963	·966 8420	49
12	·251 2248	·259 5488	·852 840	·967 9288	·255 4458	·264 2114	·784 848	·966 8234	48
13	·251 2952	·259 6264	·851 688	·967 9105	·255 5161	·264 2892	·783 734	·966 8048	47
14	·251 3656	·259 7041	·850 536	·967 8922	·255 5864	·264 3670	·782 620	·966 7862	46
15	0·251 4359	0·259 7817	3·849 386	0·967 8739	0·255 6567	0·264 4448	3·781 507	0·966 7676	45
16	·251 5063	·259 8593	·848 236	·967 8557	·255 7270	·264 5226	·780 395	·966 7490	44
17	·251 5767	·259 9370	·847 087	·967 8374	·255 7973	·264 6004	·779 283	·966 7304	43
18	·251 6471	·260 0146	·845 938	·967 8191	·255 8676	·264 6782	·778 172	·966 7118	42
19	·251 7175	·260 0922	·844 790	·967 8008	·255 9379	·264 7561	·777 062	·966 6932	41
20	0·251 7879	0·260 1699	3·843 642	0·967 7825	0·256 0082	0·264 8339	3·775 952	0·966 6746	40
21	·251 8582	·260 2475	·842 496	·967 7641	·256 0785	·264 9117	·774 843	·966 6560	39
22	·251 9286	·260 3252	·841 349	·967 7458	·256 1488	·264 9895	·773 734	·966 6374	38
23	·251 9990	·260 4028	·840 204	·967 7275	·256 2191	·265 0674	·772 626	·966 6187	37
24	·252 0694	·260 4805	·839 059	·967 7092	·256 2894	·265 1452	·771 518	·966 6001	36
25	0·252 1397	0·260 5581	3·837 915	0·967 6908	0·256 3597	0·265 2230	3·770 412	0·966 5815	35
26	·252 2101	·260 6358	·836 771	·967 6725	·256 4300	·265 3009	·769 305	·966 5628	34
27	·252 2805	·260 7135	·835 628	·967 6542	·256 5002	·265 3787	·768 200	·966 5442	33
28	·252 3508	·260 7911	·834 486	·967 6358	·256 5705	·265 4566	·767 095	·966 5255	32
29	·252 4212	·260 8688	·833 344	·967 6175	·256 6408	·265 5344	·765 990	·966 5068	31
30	0·252 4916	0·260 9465	3·832 203	0·967 5991	0·256 7111	0·265 6123	3·764 886	0·966 4882	30
31	·252 5619	·261 0242	·831 063	·967 5807	·256 7814	·265 6901	·763 783	·966 4695	29
32	·252 6323	·261 1018	·829 923	·967 5624	·256 8517	·265 7680	·762 681	·966 4508	28
33	·252 7027	·261 1795	·828 784	·967 5440	·256 9220	·265 8458	·761 579	·966 4322	27
34	·252 7730	·261 2572	·827 646	·967 5256	·256 9922	·265 9237	·760 477	·966 4135	26
35	0·252 8434	0·261 3349	3·826 508	0·967 5072	0·257 0625	0·266 0016	3·759 376	0·966 3948	25
36	·252 9137	·261 4126	·825 371	·967 4888	·257 1328	·266 0794	·758 276	·966 3761	24
37	·252 9841	·261 4903	·824 234	·967 4704	·257 2031	·266 1573	·757 177	·966 3574	23
38	·253 0545	·261 5680	·823 098	·967 4520	·257 2733	·266 2352	·756 078	·966 3387	22
39	·253 1248	·261 6457	·821 963	·967 4336	·257 3436	·266 3131	·754 979	·966 3200	21
40	0·253 1952	0·261 7234	3·820 828	0·967 4152	0·257 4139	0·266 3909	3·753 882	0·966 3012	20
41	·253 2655	·261 8011	·819 694	·967 3968	·257 4842	·266 4688	·752 784	·966 2825	19
42	·253 3359	·261 8788	·818 561	·967 3784	·257 5544	·266 5467	·751 688	·966 2638	18
43	·253 4062	·261 9565	·817 428	·967 3600	·257 6247	·266 6246	·750 592	·966 2451	17
44	·253 4766	·262 0342	·816 296	·967 3415	·257 6950	·266 7025	·749 496	·966 2263	16
45	0·253 5469	0·262 1119	3·815 164	0·967 3231	0·257 7652	0·266 7804	3·748 402	0·966 2076	15
46	·253 6173	·262 1896	·814 033	·967 3047	·257 8355	·266 8583	·747 307	·966 1888	14
47	·253 6876	·262 2674	·812 903	·967 2862	·257 9058	·266 9362	·746 214	·966 1701	13
48	·253 7579	·262 3451	·811 773	·967 2678	·257 9760	·267 0141	·745 121	·966 1513	12
49	·253 8283	·262 4228	·810 644	·967 2493	·258 0463	·267 0920	·744 028	·966 1326	11
50	0·253 8986	0·262 5005	3·809 516	0·967 2308	0·258 1165	0·267 1699	3·742 936	0·966 1138	10
51	·253 9690	·262 5783	·808 388	·967 2124	·258 1868	·267 2478	·741 845	·966 0950	09
52	·254 0393	·262 6560	·807 261	·967 1939	·258 2570	·267 3257	·740 755	·966 0762	08
53	·254 1096	·262 7338	·806 134	·967 1754	·258 3273	·267 4037	·739 665	·966 0575	07
54	·254 1800	·262 8115	·805 008	·967 1569	·258 3976	·267 4816	·738 575	·966 0387	06
55	0·254 2503	0·262 8893	3·803 883	0·967 1385	0·258 4678	0·267 5595	3·737 486	0·966 0199	05
56	·254 3206	·262 9670	·802 759	·967 1200	·258 5381	·267 6374	·736 398	·966 0011	04
57	·254 3910	·263 0448	·801 634	·967 1015	·258 6083	·267 7154	·735 310	·965 9823	03
58	·254 4613	·263 1225	·800 511	·967 0830	·258 6786	·267 7933	·734 223	·965 9635	02
59	·254 5316	·263 2003	·799 388	·967 0645	·258 7488	·267 8713	·733 137	·965 9446	01
60	0·254 6019	0·263 2780	3·798 266	0·967 0459	0·258 8190	0·267 9492	3·732 051	0·965 9258	00
									s
	cos	cot	tan	sin	cos	cot	tan	sin	
d	703–704	778–776	1122–1160	186–182	702–704	780–777	1086–1121	189–185	d
	$5^h\ 01^m$				$5^h\ 00^m$				

$1^{h}\ 00^{m}$ $1^{h}\ 01^{m}$

d	703–701	779–782	1086–1051	188–192	702–700	781–783	1051–1018	191–195	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·258 8190	0·267 9492	3·732 051	0·965 9258	0·263 0312	0·272 6313	3·667 958	0·964 7873	60
01	·258 8893	·268 0271	·730 965	·965 9070	·263 1014	·272 7094	·666 907	·964 7682	59
02	·258 9595	·268 1051	·729 881	·965 8882	·263 1715	·272 7876	·665 856	·964 7491	58
03	·259 0298	·268 1830	·728 797	·965 8693	·263 2417	·272 8657	·664 807	·964 7299	57
04	·259 1000	·268 2610	·727 713	·965 8505	·263 3118	·272 9438	·663 758	·964 7108	56
05	0·259 1702	0·268 3389	3·726 630	0·965 8317	0·263 3820	0·273 0220	3·662 709	0·964 6916	55
06	·259 2405	·268 4169	·725 548	·965 8128	·263 4522	·273 1001	·661 661	·964 6725	54
07	·259 3107	·268 4949	·724 466	·965 7939	·263 5223	·273 1783	·660 613	·964 6533	53
08	·259 3810	·268 5728	·723 385	·965 7751	·263 5925	·273 2564	·659 566	·964 6341	52
09	·259 4512	·268 6508	·722 304	·965 7562	·263 6626	·273 3346	·658 520	·964 6150	51
10	0·259 5214	0·268 7288	3·721 224	0·965 7374	0·263 7328	0·273 4127	3·657 474	0·964 5958	50
11	·259 5916	·268 8068	·720 145	·965 7185	·263 8029	·273 4909	·656 429	·964 5766	49
12	·259 6619	·268 8847	·719 066	·965 6996	·263 8730	·273 5690	·655 384	·964 5574	48
13	·259 7321	·268 9627	·717 987	·965 6807	·263 9432	·273 6472	·654 340	·964 5382	47
14	·259 8023	·269 0407	·716 910	·965 6618	·264 0133	·273 7254	·653 297	·964 5190	46
15	0·259 8726	0·269 1187	3·715 833	0·965 6429	0·264 0835	0·273 8036	3·652 254	0·964 4998	45
16	·259 9428	·269 1967	·714 756	·965 6240	·264 1536	·273 8817	·651 211	·964 4806	44
17	·260 0130	·269 2747	·713 680	·965 6051	·264 2238	·273 9599	·650 169	·964 4614	43
18	·260 0832	·269 3527	·712 605	·965 5862	·264 2939	·274 0381	·649 128	·964 4422	42
19	·260 1534	·269 4307	·711 530	·965 5673	·264 3640	·274 1163	·648 087	·964 4230	41
20	0·260 2237	0·269 5087	3·710 456	0·965 5484	0·264 4342	0·274 1945	3·647 047	0·964 4037	40
21	·260 2939	·269 5867	·709 382	·965 5294	·264 5043	·274 2727	·646 007	·964 3845	39
22	·260 3641	·269 6647	·708 309	·965 5105	·264 5744	·274 3508	·644 968	·964 3653	38
23	·260 4343	·269 7427	·707 237	·965 4916	·264 6446	·274 4290	·643 929	·964 3460	37
24	·260 5045	·269 8207	·706 165	·965 4726	·264 7147	·274 5072	·642 891	·964 3268	36
25	0·260 5747	0·269 8987	3·705 093	0·965 4537	0·264 7848	0·274 5854	3·641 854	0·964 3075	35
26	·260 6449	·269 9767	·704 023	·965 4347	·264 8549	·274 6637	·640 817	·964 2883	34
27	·260 7151	·270 0548	·702 953	·965 4158	·264 9251	·274 7419	·639 780	·964 2690	33
28	·260 7853	·270 1328	·701 883	·965 3968	·264 9952	·274 8201	·638 744	·964 2497	32
29	·260 8555	·270 2108	·700 814	·965 3778	·265 0653	·274 8983	·637 709	·964 2305	31
30	0·260 9258	0·270 2889	3·699 746	0·965 3589	0·265 1354	0·274 9765	3·636 674	0·964 2112	30
31	·260 9960	·270 3669	·698 678	·965 3399	·265 2055	·275 0547	·635 640	·964 1919	29
32	·261 0662	·270 4449	·697 610	·965 3209	·265 2757	·275 1330	·634 606	·964 1726	28
33	·261 1364	·270 5230	·696 544	·965 3019	·265 3458	·275 2112	·633 573	·964 1533	27
34	·261 2066	·270 6010	·695 477	·965 2829	·265 4159	·275 2894	·632 541	·964 1340	26
35	0·261 2767	0·270 6791	3·694 412	0·965 2639	0·265 4860	0·275 3677	3·631 509	0·964 1147	25
36	·261 3469	·270 7571	·693 347	·965 2449	·265 5561	·275 4459	·630 477	·964 0954	24
37	·261 4171	·270 8352	·692 283	·965 2259	·265 6262	·275 5241	·629 446	·964 0761	23
38	·261 4873	·270 9132	·691 219	·965 2069	·265 6963	·275 6024	·628 416	·964 0568	22
39	·261 5575	·270 9913	·690 155	·965 1879	·265 7664	·275 6806	·627 386	·964 0374	21
40	0·261 6277	0·271 0694	3·689 093	0·965 1689	0·265 8366	0·275 7589	3·626 357	0·964 0181	20
41	·261 6979	·271 1474	·688 031	·965 1498	·265 9067	·275 8371	·625 328	·963 9988	19
42	·261 7681	·271 2255	·686 969	·965 1308	·265 9768	·275 9154	·624 300	·963 9794	18
43	·261 8383	·271 3036	·685 908	·965 1118	·266 0469	·275 9936	·623 272	·963 9601	17
44	·261 9085	·271 3817	·684 848	·965 0927	·266 1170	·276 0719	·622 245	·963 9407	16
45	0·261 9786	0·271 4597	3·683 788	0·965 0737	0·266 1871	0·276 1502	3·621 218	0·963 9214	15
46	·262 0488	·271 5378	·682 728	·965 0546	·266 2572	·276 2284	·620 192	·963 9020	14
47	·262 1190	·271 6159	·681 670	·965 0356	·266 3273	·276 3067	·619 166	·963 8827	13
48	·262 1892	·271 6940	·680 611	·965 0165	·266 3973	·276 3850	·618 141	·963 8633	12
49	·262 2594	·271 7721	·679 554	·964 9974	·266 4674	·276 4633	·617 117	·963 8439	11
50	0·262 3295	0·271 8502	3·678 497	0·964 9784	0·266 5375	0·276 5416	3·616 093	0·963 8245	10
51	·262 3997	·271 9283	·677 440	·964 9593	·266 6076	·276 6198	·615 070	·963 8052	09
52	·262 4699	·272 0064	·676 384	·964 9402	·266 6777	·276 6981	·614 047	·963 7858	08
53	·262 5401	·272 0845	·675 329	·964 9211	·266 7478	·276 7764	·613 025	·963 7664	07
54	·262 6102	·272 1626	·674 274	·964 9020	·266 8179	·276 8547	·612 003	·963 7470	06
55	0·262 6804	0·272 2407	3·673 220	0·964 8829	0·266 8880	0·276 9330	3·610 982	0·963 7276	05
56	·262 7506	·272 3188	·672 166	·964 8638	·266 9581	·277 0113	·609 961	·963 7081	04
57	·262 8207	·272 3969	·671 113	·964 8447	·267 0281	·277 0896	·608 941	·963 6887	03
58	·262 8909	·272 4750	·670 061	·964 8256	·267 0982	·277 1679	·607 921	·963 6693	02
59	·262 9611	·272 5532	·669 009	·964 8064	·267 1683	·277 2462	·606 902	·963 6499	01
60	0·263 0312	0·272 6313	3·667 958	0·964 7873	0·267 2384	0·277 3245	3·605 884	0·963 6305	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	701–703	782–779	1051–1086	192–188	700–702	783–781	1018–1051	195–191	d

$4^{h}\ 59^{m}$ $4^{h}\ 58^{m}$

$1^{h}\ 02^{m}$ $1^{h}\ 03^{m}$

d	701–699	783–785	1019–987	194–198	700–699	785–787	987–958	197–201	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·267 2384	0·277 3245	3·605 884	0·963 6305	0·271 4404	0·282 0292	3·545 733	0·962 4552	60
01	·267 3085	·277 4029	·604 865	·963 6110	·271 5104	·282 1077	·544 746	·962 4355	59
02	·267 3785	·277 4812	·603 848	·963 5916	·271 5804	·282 1862	·543 760	·962 4157	58
03	·267 4486	·277 5595	·602 831	·963 5721	·271 6504	·282 2647	·542 774	·962 3960	57
04	·267 5187	·277 6378	·601 815	·963 5527	·271 7204	·282 3432	·541 789	·962 3762	56
05	0·267 5887	0·277 7162	3·600 799	0·963 5332	0·271 7904	0·282 4217	3·540 804	0·962 3565	55
06	·267 6588	·277 7945	·599 783	·963 5138	·271 8604	·282 5003	·539 820	·962 3367	54
07	·267 7289	·277 8728	·598 769	·963 4943	·271 9304	·282 5788	·538 836	·962 3169	53
08	·267 7989	·277 9512	·597 754	·963 4748	·272 0003	·282 6573	·537 853	·962 2972	52
09	·267 8690	·278 0295	·596 741	·963 4553	·272 0703	·282 7359	·536 870	·962 2774	51
10	0·267 9391	0·278 1079	3·595 727	0·963 4359	0·272 1403	0·282 8144	3·535 888	0·962 2576	50
11	·268 0091	·278 1862	·594 715	·963 4164	·272 2103	·282 8929	·534 906	·962 2378	49
12	·268 0792	·278 2646	·593 702	·963 3969	·272 2802	·282 9715	·533 925	·962 2180	48
13	·268 1493	·278 3429	·592 691	·963 3774	·272 3502	·283 0500	·532 944	·962 1982	47
14	·268 2193	·278 4213	·591 680	·963 3579	·272 4202	·283 1286	·531 964	·962 1784	46
15	0·268 2894	0·278 4996	3·590 669	0·963 3384	0·272 4902	0·283 2071	3·530 985	0·962 1586	45
16	·268 3594	·278 5780	·589 659	·963 3189	·272 5601	·283 2857	·530 005	·962 1387	44
17	·268 4295	·278 6564	·588 650	·963 2993	·272 6301	·283 3642	·529 027	·962 1189	43
18	·268 4995	·278 7347	·587 641	·963 2798	·272 7001	·283 4428	·528 049	·962 0991	42
19	·268 5696	·278 8131	·586 632	·963 2603	·272 7700	·283 5214	·527 071	·962 0793	41
20	0·268 6396	0·278 8915	3·585 624	0·963 2408	0·272 8400	0·283 5999	3·526 094	0·962 0594	40
21	·268 7097	·278 9699	·584 617	·963 2212	·272 9100	·283 6785	·525 117	·962 0396	39
22	·268 7797	·279 0482	·583 610	·963 2017	·272 9799	·283 7571	·524 141	·962 0197	38
23	·268 8498	·279 1266	·582 603	·963 1821	·273 0499	·283 8357	·523 165	·961 9999	37
24	·268 9198	·279 2050	·581 598	·963 1626	·273 1198	·283 9143	·522 190	·961 9800	36
25	0·268 9899	0·279 2834	3·580 592	0·963 1430	0·273 1898	0·283 9928	3·521 216	0·961 9602	35
26	·269 0599	·279 3618	·579 587	·963 1234	·273 2597	·284 0714	·520 241	·961 9403	34
27	·269 1299	·279 4402	·578 583	·963 1039	·273 3297	·284 1500	·519 268	·961 9204	33
28	·269 2000	·279 5186	·577 579	·963 0843	·273 3997	·284 2286	·518 295	·961 9005	32
29	·269 2700	·279 5970	·576 576	·963 0647	·273 4696	·284 3072	·517 322	·961 8806	31
30	0·269 3401	0·279 6754	3·575 573	0·963 0451	0·273 5396	0·284 3858	3·516 350	0·961 8608	30
31	·269 4101	·279 7538	·574 571	·963 0255	·273 6095	·284 4644	·515 378	·961 8409	29
32	·269 4801	·279 8322	·573 570	·963 0060	·273 6794	·284 5430	·514 407	·961 8210	28
33	·269 5502	·279 9107	·572 568	·962 9864	·273 7494	·284 6216	·513 436	·961 8011	27
34	·269 6202	·279 9891	·571 568	·962 9667	·273 8193	·284 7003	·512 466	·961 7811	26
35	0·269 6902	0·280 0675	3·570 568	0·962 9471	0·273 8893	0·284 7789	3·511 496	0·961 7612	25
36	·269 7602	·280 1459	·569 568	·962 9275	·273 9592	·284 8575	·510 527	·961 7413	24
37	·269 8303	·280 2244	·568 569	·962 9079	·274 0292	·284 9361	·509 559	·961 7214	23
38	·269 9003	·280 3028	·567 570	·962 8883	·274 0991	·285 0147	·508 590	·961 7015	22
39	·269 9703	·280 3812	·566 572	·962 8686	·274 1690	·285 0934	·507 623	·961 6815	21
40	0·270 0403	0·280 4597	3·565 575	0·962 8490	0·274 2390	0·285 1720	3·506 655	0·961 6616	20
41	·270 1103	·280 5381	·564 578	·962 8294	·274 3089	·285 2506	·505 689	·961 6416	19
42	·270 1804	·280 6166	·563 581	·962 8097	·274 3788	·285 3293	·504 723	·961 6217	18
43	·270 2504	·280 6950	·562 585	·962 7901	·274 4488	·285 4079	·503 757	·961 6017	17
44	·270 3204	·280 7735	·561 590	·962 7704	·274 5187	·285 4866	·502 792	·961 5818	16
45	0·270 3904	0·280 8519	3·560 595	0·962 7508	0·274 5886	0·285 5652	3·501 827	0·961 5618	15
46	·270 4604	·280 9304	·559 601	·962 7311	·274 6585	·285 6439	·500 863	·961 5418	14
47	·270 5304	·281 0089	·558 607	·962 7114	·274 7285	·285 7225	·499 899	·961 5219	13
48	·270 6004	·281 0873	·557 613	·962 6917	·274 7984	·285 8012	·498 936	·961 5019	12
49	·270 6705	·281 1658	·556 620	·962 6721	·274 8683	·285 8799	·497 973	·961 4819	11
50	0·270 7405	0·281 2443	3·555 628	0·962 6524	0·274 9382	0·285 9585	3·497 011	0·961 4619	10
51	·270 8105	·281 3227	·554 636	·962 6327	·275 0082	·286 0372	·496 049	·961 4419	09
52	·270 8805	·281 4012	·553 645	·962 6130	·275 0781	·286 1159	·495 087	·961 4219	08
53	·270 9505	·281 4797	·552 654	·962 5933	·275 1480	·286 1946	·494 127	·961 4019	07
54	·271 0205	·281 5582	·551 664	·962 5736	·275 2179	·286 2732	·493 166	·961 3819	06
55	0·271 0905	0·281 6367	3·550 674	0·962 5539	0·275 2878	0·286 3519	3·492 206	0·961 3619	05
56	·271 1605	·281 7152	·549 685	·962 5342	·275 3577	·286 4306	·491 247	·961 3418	04
57	·271 2305	·281 7937	·548 696	·962 5144	·275 4276	·286 5093	·490 288	·961 3218	03
58	·271 3005	·281 8722	·547 708	·962 4947	·275 4975	·286 5880	·489 330	·961 3018	02
59	·271 3705	·281 9507	·546 720	·962 4750	·275 5675	·286 6667	·488 372	·961 2817	01
60	0·271 4404	0·282 0292	3·545 733	0·962 4552	0·275 6374	0·286 7454	3·487 414	0·961 2617	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	699–701	785–783	987–1019	198–194	699–700	787–785	958–987	201–197	d

$4^{h}\ 57^{m}$ $4^{h}\ 56^{m}$

$1^h\ 04^m$ $1^h\ 05^m$

d	699–698	787–789	957–929	200–204	699–697	789–791	929–902	203–207	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·275 6374	0·286 7454	3·487 414	0·961 2617	0·279 8290	0·291 4734	3·430 845	0·960 0499	60
01	·275 7073	·286 8241	·486 458	·961 2416	·279 8988	·291 5523	·429 916	·960 0295	59
02	·275 7772	·286 9028	·485 501	·961 2216	·279 9686	·291 6312	·428 988	·960 0091	58
03	·275 8471	·286 9815	·484 545	·961 2015	·280 0385	·291 7101	·428 061	·959 9888	57
04	·275 9170	·287 0602	·483 590	·961 1815	·280 1083	·291 7890	·427 133	·959 9684	56
05	0·275 9869	0·287 1389	3·482 635	0·961 1614	0·280 1781	0·291 8680	3·426 207	0·959 9480	55
06	·276 0568	·287 2177	·481 680	·961 1413	·280 2479	·291 9469	·425 281	·959 9277	54
07	·276 1267	·287 2964	·480 726	·961 1213	·280 3177	·292 0258	·424 355	·959 9073	53
08	·276 1965	·287 3751	·479 773	·961 1012	·280 3875	·292 1047	·423 430	·959 8869	52
09	·276 2664	·287 4538	·478 820	·961 0811	·280 4573	·292 1837	·422 505	·959 8665	51
10	0·276 3363	0·287 5326	3·477 867	0·961 0610	0·280 5271	0·292 2626	3·421 581	0·959 8461	50
11	·276 4062	·287 6113	·476 915	·961 0409	·280 5969	·292 3415	·420 657	·959 8257	49
12	·276 4761	·287 6900	·475 963	·961 0208	·280 6667	·292 4205	·419 733	·959 8053	48
13	·276 5460	·287 7688	·475 012	·961 0007	·280 7365	·292 4994	·418 810	·959 7849	47
14	·276 6159	·287 8475	·474 061	·960 9806	·280 8063	·292 5784	·417 888	·959 7645	46
15	0·276 6858	0·287 9263	3·473 111	0·960 9605	0·280 8761	0·292 6573	3·416 966	0·959 7440	45
16	·276 7556	·288 0050	·472 162	·960 9403	·280 9459	·292 7363	·416 044	·959 7236	44
17	·276 8255	·288 0838	·471 212	·960 9202	·281 0157	·292 8152	·415 123	·959 7032	43
18	·276 8954	·288 1625	·470 264	·960 9001	·281 0855	·292 8942	·414 203	·959 6827	42
19	·276 9653	·288 2413	·469 315	·960 8799	·281 1553	·292 9731	·413 282	·959 6623	41
20	0·277 0352	0·288 3201	3·468 368	0·960 8598	0·281 2251	0·293 0521	3·412 363	0·959 6418	40
21	·277 1050	·288 3988	·467 420	·960 8396	·281 2948	·293 1311	·411 443	·959 6214	39
22	·277 1749	·288 4776	·466 473	·960 8195	·281 3646	·293 2100	·410 524	·959 6009	38
23	·277 2448	·288 5564	·465 527	·960 7993	·281 4344	·293 2890	·409 606	·959 5805	37
24	·277 3147	·288 6352	·464 581	·960 7792	·281 5042	·293 3680	·408 688	·959 5600	36
25	0·277 3845	0·288 7140	3·463 636	0·960 7590	0·281 5740	0·293 4470	3·407 771	0·959 5395	35
26	·277 4544	·288 7927	·462 691	·960 7388	·281 6437	·293 5260	·406 854	·959 5190	34
27	·277 5243	·288 8715	·461 747	·960 7186	·281 7135	·293 6049	·405 937	·959 4986	33
28	·277 5941	·288 9503	·460 803	·960 6984	·281 7833	·293 6839	·405 021	·959 4781	32
29	·277 6640	·289 0291	·459 859	·960 6783	·281 8531	·293 7629	·404 105	·959 4576	31
30	0·277 7338	0·289 1079	3·458 916	0·960 6581	0·281 9229	0·293 8419	3·403 190	0·959 4371	30
31	·277 8037	·289 1867	·457 974	·960 6379	·281 9926	·293 9209	·402 275	·959 4166	29
32	·277 8736	·289 2655	·457 031	·960 6177	·282 0624	·293 9999	·401 361	·959 3961	28
33	·277 9434	·289 3443	·456 090	·960 5974	·282 1322	·294 0790	·400 447	·959 3755	27
34	·278 0133	·289 4231	·455 149	·960 5772	·282 2019	·294 1580	·399 534	·959 3550	26
35	0·278 0831	0·289 5020	3·454 208	0·960 5570	0·282 2717	0·294 2370	3·398 621	0·959 3345	25
36	·278 1530	·289 5808	·453 268	·960 5368	·282 3415	·294 3160	·397 709	·959 3140	24
37	·278 2228	·289 6596	·452 328	·960 5166	·282 4112	·294 3950	·396 796	·959 2934	23
38	·278 2927	·289 7384	·451 389	·960 4963	·282 4810	·294 4741	·395 885	·959 2729	22
39	·278 3625	·289 8172	·450 450	·960 4761	·282 5507	·294 5531	·394 974	·959 2524	21
40	0·278 4324	0·289 8961	3·449 512	0·960 4558	0·282 6205	0·294 6321	3·394 063	0·959 2318	20
41	·278 5022	·289 9749	·448 574	·960 4356	·282 6903	·294 7112	·393 153	·959 2112	19
42	·278 5721	·290 0538	·447 637	·960 4153	·282 7600	·294 7902	·392 243	·959 1907	18
43	·278 6419	·290 1326	·446 700	·960 3951	·282 8298	·294 8692	·391 334	·959 1701	17
44	·278 7118	·290 2114	·445 764	·960 3748	·282 8995	·294 9483	·390 425	·959 1496	16
45	0·278 7816	0·290 2903	3·444 828	0·960 3545	0·282 9693	0·295 0273	3·389 516	0·959 1290	15
46	·278 8514	·290 3691	·443 892	·960 3343	·283 0390	·295 1064	·388 608	·959 1084	14
47	·278 9213	·290 4480	·442 957	·960 3140	·283 1088	·295 1854	·387 701	·959 0878	13
48	·278 9911	·290 5269	·442 023	·960 2937	·283 1785	·295 2645	·386 794	·959 0672	12
49	·279 0609	·290 6057	·441 089	·960 2734	·283 2483	·295 3436	·385 887	·959 0466	11
50	0·279 1308	0·290 6846	3·440 155	0·960 2531	0·283 3180	0·295 4226	3·384 981	0·959 0260	10
51	·279 2006	·290 7635	·439 222	·960 2328	·283 3877	·295 5017	·384 075	·959 0054	09
52	·279 2704	·290 8423	·438 289	·960 2125	·283 4575	·295 5808	·383 170	·958 9848	08
53	·279 3403	·290 9212	·437 357	·960 1922	·283 5272	·295 6599	·382 265	·958 9642	07
54	·279 4101	·291 0001	·436 425	·960 1719	·283 5970	·295 7389	·381 361	·958 9436	06
55	0·279 4799	0·291 0790	3·435 494	0·960 1515	0·283 6667	0·295 8180	3·380 457	0·958 9229	05
56	·279 5497	·291 1578	·434 563	·960 1312	·283 7364	·295 8971	·379 553	·958 9023	04
57	·279 6196	·291 2367	·433 633	·960 1109	·283 8062	·295 9762	·378 650	·958 8817	03
58	·279 6894	·291 3156	·432 703	·960 0905	·283 8759	·296 0553	·377 747	·958 8610	02
59	·279 7592	·291 3945	·431 774	·960 0702	·283 9456	·296 1344	·376 845	·958 8404	01
60	0·279 8290	0·291 4734	3·430 845	0·960 0499	0·284 0153	0·296 2135	3·375 943	0·958 8197	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	698–699	789–787	929–957	204–200	697–699	791–789	902–929	207–203	d

$4^h\ 55^m$ $4^h\ 54^m$

1^{h} 06^{m} 1^{h} 07^{m}

d	698–696	791–793	901–876	206–210	697–695	793–796	875–851	209–213	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·284 0153	0·296 2135	3·375 943	0·958 8197	0·288 1963	0·300 9658	3·322 636	0·957 5714	60
01	·284 0851	·296 2926	·375 042	·958 7991	·288 2659	·301 0452	·321 761	·957 5504	59
02	·284 1548	·296 3717	·374 141	·958 7784	·288 3355	·301 1245	·320 886	·957 5294	58
03	·284 2245	·296 4508	·373 241	·958 7577	·288 4052	·301 2038	·320 011	·957 5085	57
04	·284 2942	·296 5299	·372 341	·958 7371	·288 4748	·301 2831	·319 137	·957 4875	56
05	0·284 3640	0·296 6091	3·371 441	0·958 7164	0·288 5444	0·301 3624	3·318 264	0·957 4665	55
06	·284 4337	·296 6882	·370 542	·958 6957	·288 6141	·301 4418	·317 390	·957 4455	54
07	·284 5034	·296 7673	·369 644	·958 6750	·288 6837	·301 5211	·316 518	·957 4245	53
08	·284 5731	·296 8464	·368 745	·958 6543	·288 7533	·301 6004	·315 645	·957 4035	52
09	·284 6428	·296 9256	·367 847	·958 6336	·288 8229	·301 6798	·314 773	·957 3825	51
10	0·284 7125	0·297 0047	3·366 950	0·958 6129	0·288 8926	0·301 7591	3·313 902	0·957 3615	50
11	·284 7823	·297 0838	·366 053	·958 5922	·288 9622	·301 8385	·313 031	·957 3405	49
12	·284 8520	·297 1630	·365 157	·958 5715	·289 0318	·301 9178	·312 160	·957 3195	48
13	·284 9217	·297 2421	·364 261	·958 5508	·289 1014	·301 9972	·311 289	·957 2985	47
14	·284 9914	·297 3213	·363 365	·958 5301	·289 1710	·302 0765	·310 420	·957 2774	46
15	0·285 0611	0·297 4004	3·362 470	0·958 5094	0·289 2406	0·302 1559	3·309 550	0·957 2564	45
16	·285 1308	·297 4796	·361 575	·958 4886	·289 3103	·302 2352	·308 681	·957 2354	44
17	·285 2005	·297 5587	·360 681	·958 4679	·289 3799	·302 3146	·307 812	·957 2143	43
18	·285 2702	·297 6379	·359 787	·958 4471	·289 4495	·302 3940	·306 944	·957 1933	42
19	·285 3399	·297 7171	·358 894	·958 4264	·289 5191	·302 4733	·306 076	·957 1722	41
20	0·285 4096	0·297 7962	3·358 001	0·958 4056	0·289 5887	0·302 5527	3·305 209	0·957 1512	40
21	·285 4793	·297 8754	·357 108	·958 3849	·289 6583	·302 6321	·304 342	·957 1301	39
22	·285 5490	·297 9546	·356 216	·958 3641	·289 7279	·302 7115	·303 476	·957 1091	38
23	·285 6187	·298 0338	·355 325	·958 3433	·289 7975	·302 7909	·302 609	·957 0880	37
24	·285 6884	·298 1129	·354 433	·958 3226	·289 8671	·302 8703	·301 744	·957 0669	36
25	0·285 7581	0·298 1921	3·353 543	0·958 3018	0·289 9367	0·302 9497	3·300 878	0·957 0458	35
26	·285 8277	·298 2713	·352 652	·958 2810	·290 0063	·303 0291	·300 014	·957 0247	34
27	·285 8974	·298 3505	·351 762	·958 2602	·290 0759	·303 1085	·299 149	·957 0036	33
28	·285 9671	·298 4297	·350 873	·958 2394	·290 1455	·303 1879	·298 285	·956 9825	32
29	·286 0368	·298 5089	·349 984	·958 2186	·290 2151	·303 2673	·297 421	·956 9614	31
30	0·286 1065	0·298 5881	3·349 095	0·958 1978	0·290 2847	0·303 3467	3·296 558	0·956 9403	30
31	·286 1762	·298 6673	·348 207	·958 1770	·290 3543	·303 4261	·295 695	·956 9192	29
32	·286 2458	·298 7465	·347 319	·958 1562	·290 4239	·303 5055	·294 833	·956 8981	28
33	·286 3155	·298 8258	·346 432	·958 1354	·290 4934	·303 5849	·293 971	·956 8770	27
34	·286 3852	·298 9050	·345 545	·958 1146	·290 5630	·303 6644	·293 109	·956 8559	26
35	0·286 4549	0·298 9842	3·344 658	0·958 0937	0·290 6326	0·303 7438	3·292 248	0·956 8347	25
36	·286 5246	·299 0634	·343 772	·958 0729	·290 7022	·303 8232	·291 388	·956 8136	24
37	·286 5942	·299 1426	·342 887	·958 0521	·290 7718	·303 9027	·290 527	·956 7924	23
38	·286 6639	·299 2219	·342 002	·958 0312	·290 8414	·303 9821	·289 667	·956 7713	22
39	·286 7336	·299 3011	·341 117	·958 0104	·290 9109	·304 0616	·288 808	·956 7501	21
40	0·286 8032	0·299 3803	3·340 233	0·957 9895	0·290 9805	0·304 1410	3·287 949	0·956 7290	20
41	·286 8729	·299 4596	·339 349	·957 9687	·291 0501	·304 2204	·287 090	·956 7078	19
42	·286 9426	·299 5388	·338 465	·957 9478	·291 1197	·304 2999	·286 232	·956 6867	18
43	·287 0122	·299 6181	·337 582	·957 9269	·291 1892	·304 3794	·285 374	·956 6655	17
44	·287 0819	·299 6973	·336 700	·957 9060	·291 2588	·304 4588	·284 516	·956 6443	16
45	0·287 1515	0·299 7766	3·335 818	0·957 8852	0·291 3284	0·304 5383	3·283 659	0·956 6231	15
46	·287 2212	·299 8558	·334 936	·957 8643	·291 3979	·304 6178	·282 803	·956 6019	14
47	·287 2909	·299 9351	·334 054	·957 8434	·291 4675	·304 6972	·281 947	·956 5807	13
48	·287 3605	·300 0144	·333 174	·957 8225	·291 5371	·304 7767	·281 091	·956 5595	12
49	·287 4302	·300 0936	·332 293	·957 8016	·291 6066	·304 8562	·280 235	·956 5383	11
50	0·287 4998	0·300 1729	3·331 413	0·957 7807	0·291 6762	0·304 9357	3·279 380	0·956 5171	10
51	·287 5695	·300 2522	·330 534	·957 7598	·291 7457	·305 0151	·278 526	·956 4959	09
52	·287 6391	·300 3315	·329 654	·957 7389	·291 8153	·305 0946	·277 671	·956 4747	08
53	·287 7088	·300 4108	·328 776	·957 7179	·291 8849	·305 1741	·276 818	·956 4535	07
54	·287 7784	·300 4900	·327 897	·957 6970	·291 9544	·305 2536	·275 964	·956 4322	06
55	0·287 8481	0·300 5693	3·327 019	0·957 6761	0·292 0240	0·305 3331	3·275 111	0·956 4110	05
56	·287 9177	·300 6486	·326 142	·957 6552	·292 0935	·305 4126	·274 259	·956 3898	04
57	·287 9874	·300 7279	·325 265	·957 6342	·292 1631	·305 4921	·273 407	·956 3685	03
58	·288 0570	·300 8072	·324 388	·957 6133	·292 2326	·305 5716	·272 555	·956 3473	02
59	·288 1266	·300 8865	·323 512	·957 5923	·292 3022	·305 6512	·271 704	·956 3260	01
60	0·288 1963	0·300 9658	3·322 636	0·957 5714	0·292 3717	0·305 7307	3·270 853	0·956 3048	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	696–698	793–791	876–901	210–206	695–697	796–793	851–875	213–209	d

4^{h} 53^{m} 4^{h} 52^{m}

$1^{h}\ 08^{m}$ $1^{h}\ 09^{m}$

d	696–694	795–798	851–827	212–216	695–693	797–800	827–804	215–219	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·292 3717	0·305 7307	3·270 853	0·956 3048	0·296 5416	0·310 5083	3·220 526	0·955 0199	60
01	·292 4412	·305 8102	·270 002	·956 2835	·296 6110	·310 5880	·219 700	·954 9984	59
02	·292 5108	·305 8897	·269 152	·956 2622	·296 6805	·310 6677	·218 873	·954 9768	58
03	·292 5803	·305 9693	·268 302	·956 2409	·296 7499	·310 7475	·218 047	·954 9552	57
04	·292 6499	·306 0488	·267 453	·956 2197	·296 8194	·310 8272	·217 221	·954 9336	56
05	0·292 7194	0·306 1283	3·266 604	0·956 1984	0·296 8888	0·310 9070	3·216 396	0·954 9121	55
06	·292 7889	·306 2079	·265 755	·956 1771	·296 9583	·310 9867	·215 571	·954 8905	54
07	·292 8585	·306 2874	·264 907	·956 1558	·297 0277	·311 0665	·214 747	·954 8689	53
08	·292 9280	·306 3670	·264 060	·956 1345	·297 0971	·311 1462	·213 923	·954 8473	52
09	·292 9975	·306 4465	·263 212	·956 1132	·297 1666	·311 2260	·213 099	·954 8257	51
10	0·293 0671	0·306 5261	3·262 365	0·956 0919	0·297 2360	0·311 3058	3·212 276	0·954 8040	50
11	·293 1366	·306 6056	·261 519	·956 0706	·297 3054	·311 3855	·211 453	·954 7824	49
12	·293 2061	·306 6852	·260 673	·956 0492	·297 3749	·311 4653	·210 630	·954 7608	48
13	·293 2757	·306 7647	·259 827	·956 0279	·297 4443	·311 5451	·209 808	·954 7392	47
14	·293 3452	·306 8443	·258 982	·956 0066	·297 5137	·311 6249	·208 986	·954 7175	46
15	0·293 4147	0·306 9239	3·258 137	0·955 9853	0·297 5832	0·311 7047	3·208 165	0·954 6959	45
16	·293 4842	·307 0034	·257 292	·955 9639	·297 6526	·311 7845	·207 344	·954 6743	44
17	·293 5537	·307 0830	·256 448	·955 9426	·297 7220	·311 8642	·206 523	·954 6526	43
18	·293 6233	·307 1626	·255 605	·955 9212	·297 7914	·311 9440	·205 703	·954 6310	42
19	·293 6928	·307 2422	·254 761	·955 8999	·297 8609	·312 0238	·204 883	·954 6093	41
20	0·293 7623	0·307 3218	3·253 918	0·955 8785	0·297 9303	0·312 1036	3·204 064	0·954 5876	40
21	·293 8318	·307 4014	·253 076	·955 8571	·297 9997	·312 1835	·203 245	·954 5660	39
22	·293 9013	·307 4810	·252 234	·955 8358	·298 0691	·312 2633	·202 426	·954 5443	38
23	·293 9708	·307 5606	·251 392	·955 8144	·298 1385	·312 3431	·201 608	·954 5226	37
24	·294 0403	·307 6402	·250 551	·955 7930	·298 2079	·312 4229	·200 790	·954 5009	36
25	0·294 1098	0·307 7198	3·249 710	0·955 7716	0·298 2774	0·312 5027	3·199 972	0·954 4792	35
26	·294 1793	·307 7994	·248 869	·955 7502	·298 3468	·312 5825	·199 155	·954 4575	34
27	·294 2488	·307 8790	·248 029	·955 7288	·298 4162	·312 6624	·198 338	·954 4358	33
28	·294 3183	·307 9586	·247 190	·955 7074	·298 4856	·312 7422	·197 522	·954 4141	32
29	·294 3878	·308 0382	·246 350	·955 6860	·298 5550	·312 8220	·196 706	·954 3924	31
30	0·294 4573	0·308 1179	3·245 511	0·955 6646	0·298 6244	0·312 9019	3·195 890	0·954 3707	30
31	·294 5268	·308 1975	·244 673	·955 6432	·298 6938	·312 9817	·195 075	·954 3490	29
32	·294 5963	·308 2771	·243 835	·955 6218	·298 7632	·313 0616	·194 260	·954 3273	28
33	·294 6658	·308 3568	·242 997	·955 6004	·298 8326	·313 1414	·193 445	·954 3055	27
34	·294 7353	·308 4364	·242 160	·955 5789	·298 9020	·313 2213	·192 631	·954 2838	26
35	0·294 8048	0·308 5160	3·241 323	0·955 5575	0·298 9714	0·313 3011	3·191 817	0·954 2621	25
36	·294 8743	·308 5957	·240 486	·955 5361	·299 0408	·313 3810	·191 004	·954 2403	24
37	·294 9438	·308 6753	·239 650	·955 5146	·299 1102	·313 4609	·190 191	·954 2186	23
38	·295 0133	·308 7550	·238 814	·955 4932	·299 1796	·313 5407	·189 378	·954 1968	22
39	·295 0828	·308 8346	·237 979	·955 4717	·299 2490	·313 6206	·188 566	·954 1751	21
40	0·295 1522	0·308 9143	3·237 144	0·955 4502	0·299 3184	0·313 7005	3·187 754	0·954 1533	20
41	·295 2217	·308 9940	·236 309	·955 4288	·299 3877	·313 7804	·186 943	·954 1315	19
42	·295 2912	·309 0736	·235 475	·955 4073	·299 4571	·313 8603	·186 131	·954 1098	18
43	·295 3607	·309 1533	·234 641	·955 3858	·299 5265	·313 9401	·185 321	·954 0880	17
44	·295 4302	·309 2330	·233 808	·955 3643	·299 5959	·314 0200	·184 510	·954 0662	16
45	0·295 4996	0·309 3127	3·232 975	0·955 3429	0·299 6653	0·314 0999	3·183 700	0·954 0444	15
46	·295 5691	·309 3923	·232 142	·955 3214	·299 7347	·314 1798	·182 891	·954 0226	14
47	·295 6386	·309 4720	·231 310	·955 2999	·299 8040	·314 2597	·182 081	·954 0008	13
48	·295 7081	·309 5517	·230 478	·955 2784	·299 8734	·314 3396	·181 272	·953 9790	12
49	·295 7775	·309 6314	·229 647	·955 2569	·299 9428	·314 4195	·180 464	·953 9572	11
50	0·295 8470	0·309 7111	3·228 816	0·955 2353	0·300 0122	0·314 4995	3·179 656	0·953 9354	10
51	·295 9165	·309 7908	·227 985	·955 2138	·300 0815	·314 5794	·178 848	·953 9136	09
52	·295 9859	·309 8705	·227 155	·955 1923	·300 1509	·314 6593	·178 041	·953 8917	08
53	·296 0554	·309 9502	·226 325	·955 1708	·300 2203	·314 7392	·177 234	·953 8699	07
54	·296 1248	·310 0299	·225 495	·955 1492	·300 2896	·314 8191	·176 427	·953 8481	06
55	0·296 1943	0·310 1096	3·224 666	0·955 1277	0·300 3590	0·314 8991	3·175 621	0·953 8262	05
56	·296 2638	·310 1893	·223 837	·955 1062	·300 4284	·314 9790	·174 815	·953 8044	04
57	·296 3332	·310 2691	·223 009	·955 0846	·300 4977	·315 0590	·174 009	·953 7825	03
58	·296 4027	·310 3488	·222 181	·955 0631	·300 5671	·315 1389	·173 204	·953 7607	02
59	·296 4721	·310 4285	·221 353	·955 0415	·300 6364	·315 2188	·172 399	·953 7388	01
60	0·296 5416	0·310 5083	3·220 526	0·955 0199	0·300 7058	0·315 2988	3·171 595	0·953 7170	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	694–696	798–795	827–851	216–212	693–695	800–797	804–827	219–215	d

$4^{h}\ 51^{m}$ $4^{h}\ 50^{m}$

$1^{h}\ 10^{m}$ $1^{h}\ 11^{m}$

d	694–692	799–802	804–783	218–222	693–691	801–804	782–761	221–225	d
	sin	tan	cot	cos	sin	tan	cot	cos	
s									
00	0·300 7058	0·315 2988	3·171 595	0·953 7170	0·304 8643	0·320 1025	3·123 999	0·952 3958	60
01	·300 7752	·315 3787	·170 791	·953 6951	·304 9336	·320 1827	·123 217	·952 3736	59
02	·300 8445	·315 4587	·169 987	·953 6732	·305 0028	·320 2629	·122 435	·952 3514	58
03	·300 9139	·315 5387	·169 184	·953 6513	·305 0721	·320 3431	·121 653	·952 3293	57
04	·300 9832	·315 6186	·168 381	·953 6294	·305 1413	·320 4232	·120 872	·952 3071	56
05	0·301 0526	0·315 6986	3·167 578	0·953 6075	0·305 2106	0·320 5034	3·120 091	0·952 2849	55
06	·301 1219	·315 7786	·166 776	·953 5857	·305 2798	·320 5836	·119 311	·952 2627	54
07	·301 1913	·315 8585	·165 974	·953 5638	·305 3491	·320 6638	·118 531	·952 2405	53
08	·301 2606	·315 9385	·165 173	·953 5418	·305 4183	·320 7440	·117 751	·952 2183	52
09	·301 3299	·316 0185	·164 372	·953 5199	·305 4876	·320 8242	·116 971	·952 1961	51
10	0·301 3993	0·316 0985	3·163 571	0·953 4980	0·305 5568	0·320 9044	3·116 192	0·952 1738	50
11	·301 4686	·316 1785	·162 771	·953 4761	·305 6261	·320 9847	·115 414	·952 1516	49
12	·301 5380	·316 2585	·161 971	·953 4542	·305 6953	·321 0649	·114 635	·952 1294	48
13	·301 6073	·316 3385	·161 171	·953 4322	·305 7645	·321 1451	·113 857	·952 1072	47
14	·301 6766	·316 4185	·160 372	·953 4103	·305 8338	·321 2253	·113 080	·952 0849	46
15	0·301 7460	0·316 4985	3·159 573	0·953 3884	0·305 9030	0·321 3055	3·112 302	0·952 0627	45
16	·301 8153	·316 5785	·158 774	·953 3664	·305 9723	·321 3858	·111 525	·952 0404	44
17	·301 8846	·316 6585	·157 976	·953 3445	·306 0415	·321 4660	·110 749	·952 0182	43
18	·301 9540	·316 7385	·157 178	·953 3225	·306 1107	·321 5463	·109 972	·951 9959	42
19	·302 0233	·316 8185	·156 381	·953 3005	·306 1800	·321 6265	·109 197	·951 9737	41
20	0·302 0926	0·316 8986	3·155 584	0·953 2786	0·306 2492	0·321 7067	3·108 421	0·951 9514	40
21	·302 1619	·316 9786	·154 787	·953 2566	·306 3184	·321 7870	·107 646	·951 9291	39
22	·302 2313	·317 0586	·153 991	·953 2346	·306 3876	·321 8672	·106 871	·951 9068	38
23	·302 3006	·317 1386	·153 195	·953 2127	·306 4569	·321 9475	·106 096	·951 8845	37
24	·302 3699	·317 2187	·152 399	·953 1907	·306 5261	·322 0278	·105 322	·951 8623	36
25	0·302 4392	0·317 2987	3·151 604	0·953 1687	0·306 5953	0·322 1080	3·104 548	0·951 8400	35
26	·302 5085	·317 3788	·150 809	·953 1467	·306 6645	·322 1883	·103 775	·951 8177	34
27	·302 5778	·317 4588	·150 015	·953 1247	·306 7337	·322 2686	·103 002	·951 7954	33
28	·302 6471	·317 5389	·149 221	·953 1027	·306 8030	·322 3489	·102 229	·951 7731	32
29	·302 7165	·317 6189	·148 427	·953 0807	·306 8722	·322 4291	·101 457	·951 7507	31
30	0·302 7858	0·317 6990	3·147 634	0·953 0586	0·306 9414	0·322 5094	3·100 685	0·951 7284	30
31	·302 8551	·317 7791	·146 840	·953 0366	·307 0106	·322 5897	·099 913	·951 7061	29
32	·302 9244	·317 8591	·146 048	·953 0146	·307 0798	·322 6700	·099 142	·951 6838	28
33	·302 9937	·317 9392	·145 256	·952 9926	·307 1490	·322 7503	·098 371	·951 6614	27
34	·303 0630	·318 0193	·144 464	·952 9705	·307 2182	·322 8306	·097 600	·951 6391	26
35	0·303 1323	0·318 0993	3·143 672	0·952 9485	0·307 2874	0·322 9109	3·096 830	0·951 6168	25
36	·303 2016	·318 1794	·142 881	·952 9264	·307 3566	·322 9912	·096 060	·951 5944	24
37	·303 2709	·318 2595	·142 090	·952 9044	·307 4258	·323 0715	·095 290	·951 5720	23
38	·303 3402	·318 3396	·141 299	·952 8823	·307 4950	·323 1518	·094 521	·951 5497	22
39	·303 4095	·318 4197	·140 509	·952 8603	·307 5642	·323 2321	·093 752	·951 5273	21
40	0·303 4788	0·318 4998	3·139 719	0·952 8382	0·307 6334	0·323 3125	3·092 983	0·951 5050	20
41	·303 5481	·318 5799	·138 930	·952 8161	·307 7026	·323 3928	·092 215	·951 4826	19
42	·303 6174	·318 6600	·138 141	·952 7941	·307 7718	·323 4731	·091 447	·951 4602	18
43	·303 6866	·318 7401	·137 352	·952 7720	·307 8410	·323 5535	·090 679	·951 4378	17
44	·303 7559	·318 8202	·136 564	·952 7499	·307 9102	·323 6338	·089 912	·951 4154	16
45	0·303 8252	0·318 9003	3·135 776	0·952 7278	0·307 9794	0·323 7141	3·089 145	0·951 3930	15
46	·303 8945	·318 9805	·134 988	·952 7057	·308 0486	·323 7945	·088 379	·951 3706	14
47	·303 9638	·319 0606	·134 201	·952 6836	·308 1177	·323 8748	·087 613	·951 3482	13
48	·304 0331	·319 1407	·133 414	·952 6615	·308 1869	·323 9552	·086 847	·951 3258	12
49	·304 1023	·319 2208	·132 628	·952 6394	·308 2561	·324 0355	·086 081	·951 3034	11
50	0·304 1716	0·319 3010	3·131 841	0·952 6173	0·308 3253	0·324 1159	3·085 316	0·951 2810	10
51	·304 2409	·319 3811	·131 056	·952 5951	·308 3945	·324 1963	·084 551	·951 2586	09
52	·304 3102	·319 4613	·130 270	·952 5730	·308 4636	·324 2766	·083 787	·951 2361	08
53	·304 3794	·319 5414	·129 485	·952 5509	·308 5328	·324 3570	·083 023	·951 2137	07
54	·304 4487	·319 6215	·128 700	·952 5287	·308 6020	·324 4374	·082 259	·951 1913	06
55	0·304 5180	0·319 7017	3·127 916	0·952 5066	0·308 6712	0·324 5177	3·081 496	0·951 1688	05
56	·304 5872	·319 7819	·127 132	·952 4844	·308 7403	·324 5981	·080 732	·951 1464	04
57	·304 6565	·319 8620	·126 348	·952 4623	·308 8095	·324 6785	·079 970	·951 1239	03
58	·304 7258	·319 9422	·125 565	·952 4401	·308 8787	·324 7589	·079 207	·951 1015	02
59	·304 7950	·320 0224	·124 782	·952 4180	·308 9478	·324 8393	·078 445	·951 0790	01
60	0·304 8643	0·320 1025	3·123 999	0·952 3958	0·309 0170	0·324 9197	3·077 684	0·951 0565	00
									s
	cos	cot	tan	sin	cos	cot	tan	sin	
d	692–694	802–799	783–804	222–218	691–693	804–801	761–782	225–221	d

$4^{h}\ 49^{m}$ $4^{h}\ 48^{m}$

$1^{h}\ 12^{m}$ $1^{h}\ 13^{m}$

d	692–690	804–807	762–742	224–228	691–689	806–809	741–722	227–231	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·309 0170	0·324 9197	3·077 684	0·951 0565	0·313 1638	0·329 7505	3·032 595	0·949 6991	60
01	·309 0862	·325 0001	·076 922	·951 0340	·313 2329	·329 8312	·031 854	·949 6763	59
02	·309 1553	·325 0805	·076 161	·951 0116	·313 3019	·329 9118	·031 113	·949 6536	58
03	·309 2245	·325 1609	·075 400	·950 9891	·313 3710	·329 9925	·030 372	·949 6308	57
04	·309 2936	·325 2413	·074 640	·950 9666	·313 4400	·330 0731	·029 632	·949 6080	56
05	0·309 3628	0·325 3217	3·073 880	0·950 9441	0·313 5091	0·330 1537	3·028 892	0·949 5852	55
06	·309 4319	·325 4022	·073 120	·950 9216	·313 5782	·330 2344	·028 152	·949 5624	54
07	·309 5011	·325 4826	·072 361	·950 8991	·313 6472	·330 3150	·027 413	·949 5396	53
08	·309 5702	·325 5630	·071 602	·950 8766	·313 7163	·330 3957	·026 674	·949 5168	52
09	·309 6394	·325 6434	·070 843	·950 8541	·313 7853	·330 4764	·025 935	·949 4940	51
10	0·309 7085	0·325 7239	3·070 085	0·950 8315	0·313 8544	0·330 5570	3·025 197	0·949 4711	50
11	·309 7777	·325 8043	·069 327	·950 8090	·313 9234	·330 6377	·024 458	·949 4483	49
12	·309 8468	·325 8848	·068 569	·950 7865	·313 9925	·330 7184	·023 721	·949 4255	48
13	·309 9160	·325 9652	·067 812	·950 7640	·314 0615	·330 7991	·022 983	·949 4026	47
14	·309 9851	·326 0457	·067 055	·950 7414	·314 1305	·330 8797	·022 246	·949 3798	46
15	0·310 0543	0·326 1261	3·066 298	0·950 7189	0·314 1996	0·330 9604	3·021 509	0·949 3570	45
16	·310 1234	·326 2066	·065 542	·950 6963	·314 2686	·331 0411	·020 773	·949 3341	44
17	·310 1925	·326 2870	·064 786	·950 6738	·314 3377	·331 1218	·020 037	·949 3112	43
18	·310 2617	·326 3675	·064 031	·950 6512	·314 4067	·331 2025	·019 301	·949 2884	42
19	·310 3308	·326 4480	·063 275	·950 6286	·314 4757	·331 2832	·018 565	·949 2655	41
20	0·310 3999	0·326 5284	3·062 520	0·950 6061	0·314 5448	0·331 3639	3·017 830	0·949 2426	40
21	·310 4691	·326 6089	·061 766	·950 5835	·314 6138	·331 4446	·017 095	·949 2198	39
22	·310 5382	·326 6894	·061 011	·950 5609	·314 6828	·331 5253	·016 361	·949 1969	38
23	·310 6073	·326 7699	·060 257	·950 5383	·314 7518	·331 6061	·015 627	·949 1740	37
24	·310 6764	·326 8504	·059 504	·950 5157	·314 8209	·331 6868	·014 893	·949 1511	36
25	0·310 7456	0·326 9309	3·058 751	0·950 4931	0·314 8899	0·331 7675	3·014 159	0·949 1282	35
26	·310 8147	·327 0114	·057 998	·950 4705	·314 9589	·331 8482	·013 426	·949 1053	34
27	·310 8838	·327 0919	·057 245	·950 4479	·315 0279	·331 9290	·012 693	·949 0824	33
28	·310 9529	·327 1724	·056 493	·950 4253	·315 0969	·332 0097	·011 960	·949 0595	32
29	·311 0220	·327 2529	·055 741	·950 4027	·315 1660	·332 0904	·011 228	·949 0366	31
30	0·311 0911	0·327 3334	3·054 989	0·950 3801	0·315 2350	0·332 1712	3·010 496	0·949 0136	30
31	·311 1603	·327 4139	·054 238	·950 3575	·315 3040	·332 2519	·009 764	·948 9907	29
32	·311 2294	·327 4944	·053 487	·950 3348	·315 3730	·332 3327	·009 033	·948 9678	28
33	·311 2985	·327 5750	·052 736	·950 3122	·315 4420	·332 4134	·008 302	·948 9449	27
34	·311 3676	·327 6555	·051 986	·950 2896	·315 5110	·332 4942	·007 571	·948 9219	26
35	0·311 4367	0·327 7360	3·051 236	0·950 2669	0·315 5800	0·332 5750	3·006 841	0·948 8990	25
36	·311 5058	·327 8165	·050 487	·950 2443	·315 6490	·332 6557	·006 111	·948 8760	24
37	·311 5749	·327 8971	·049 737	·950 2216	·315 7180	·332 7365	·005 381	·948 8531	23
38	·311 6440	·327 9776	·048 988	·950 1989	·315 7870	·332 8173	·004 652	·948 8301	22
39	·311 7131	·328 0582	·048 240	·950 1763	·315 8560	·332 8981	·003 923	·948 8071	21
40	0·311 7822	0·328 1387	3·047 492	0·950 1536	0·315 9250	0·332 9788	3·003 194	0·948 7842	20
41	·311 8513	·328 2193	·046 744	·950 1309	·315 9940	·333 0596	·002 465	·948 7612	19
42	·311 9204	·328 2998	·045 996	·950 1082	·316 0630	·333 1404	·001 737	·948 7382	18
43	·311 9895	·328 3804	·045 249	·950 0856	·316 1320	·333 2212	·001 009	·948 7152	17
44	·312 0586	·328 4610	·044 502	·950 0629	·316 2010	·333 3020	3·000 282	·948 6922	16
45	0·312 1277	0·328 5415	3·043 755	0·950 0402	0·316 2700	0·333 3828	2·999 555	0·948 6692	15
46	·312 1967	·328 6221	·043 009	·950 0175	·316 3390	·333 4636	·998 828	·948 6462	14
47	·312 2658	·328 7027	·042 263	·949 9948	·316 4080	·333 5444	·998 101	·948 6232	13
48	·312 3349	·328 7833	·041 517	·949 9721	·316 4770	·333 6252	·997 375	·948 6002	12
49	·312 4040	·328 8639	·040 772	·949 9493	·316 5460	·333 7061	·996 649	·948 5772	11
50	0·312 4731	0·328 9444	3·040 027	0·949 9266	0·316 6149	0·333 7869	2·995 924	0·948 5542	10
51	·312 5422	·329 0250	·039 282	·949 9039	·316 6839	·333 8677	·995 198	·948 5311	09
52	·312 6112	·329 1056	·038 538	·949 8812	·316 7529	·333 9485	·994 473	·948 5081	08
53	·312 6803	·329 1862	·037 794	·949 8584	·316 8219	·334 0294	·993 749	·948 4851	07
54	·312 7494	·329 2668	·037 050	·949 8357	·316 8908	·334 1102	·993 024	·948 4620	06
55	0·312 8185	0·329 3474	3·036 307	0·949 8129	0·316 9598	0·334 1911	2·992 300	0·948 4390	05
56	·312 8875	·329 4281	·035 564	·949 7902	·317 0288	·334 2719	·991 577	·948 4159	04
57	·312 9566	·329 5087	·034 821	·949 7674	·317 0978	·334 3527	·990 853	·948 3929	03
58	·313 0257	·329 5893	·034 079	·949 7447	·317 1667	·334 4336	·990 130	·948 3698	02
59	·313 0947	·329 6699	·033 337	·949 7219	·317 2357	·334 5145	·989 407	·948 3467	01
60	0·313 1638	0·329 7505	3·032 595	0·949 6991	0·317 3047	0·334 5953	2·988 685	0·948 3237	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	690–692	807–804	742–762	228–224	689–691	809–806	722–741	231–227	d

$4^{h}\ 47^{m}$ $4^{h}\ 46^{m}$

	$1^{h}\ 14^{m}$				$1^{h}\ 15^{m}$				
d	690–688	808–811	722–704	231–234	689–687	811–814	704–686	233–237	d
	sin	tan	cot	cos	sin	tan	cot	cos	
s									
00	0·317 3047	0·334 5953	2·988 685	0·948 3237	0·321 4395	0·339 4543	2·945 905	0·946 9301	60
01	·317 3736	·334 6762	·987 963	·948 3006	·321 5083	·339 5354	·945 201	·946 9068	59
02	·317 4426	·334 7571	·987 241	·948 2775	·321 5772	·339 6165	·944 498	·946 8834	58
03	·317 5115	·334 8379	·986 519	·948 2544	·321 6460	·339 6976	·943 795	·946 8600	57
04	·317 5805	·334 9188	·985 798	·948 2313	·321 7149	·339 7787	·943 092	·946 8366	56
05	0·317 6495	0·334 9997	2·985 077	0·948 2082	0·321 7838	0·339 8598	2·942 390	0·946 8132	55
06	·317 7184	·335 0806	·984 357	·948 1851	·321 8526	·339 9409	·941 687	·946 7898	54
07	·317 7874	·335 1615	·983 637	·948 1620	·321 9215	·340 0221	·940 986	·946 7664	53
08	·317 8563	·335 2424	·982 917	·948 1389	·321 9903	·340 1032	·940 284	·946 7430	52
09	·317 9253	·335 3233	·982 197	·948 1158	·322 0592	·340 1843	·939 583	·946 7195	51
10	0·317 9942	0·335 4042	2·981 478	0·948 0927	0·322 1280	0·340 2655	2·938 882	0·946 6961	50
11	·318 0632	·335 4851	·980 759	·948 0695	·322 1969	·340 3466	·938 181	·946 6727	49
12	·318 1321	·335 5660	·980 040	·948 0464	·322 2657	·340 4278	·937 481	·946 6493	48
13	·318 2010	·335 6469	·979 322	·948 0233	·322 3345	·340 5089	·936 781	·946 6258	47
14	·318 2700	·335 7278	·978 604	·948 0001	·322 4034	·340 5901	·936 081	·946 6024	46
15	0·318 3389	0·335 8087	2·977 886	0·947 9770	0·322 4722	0·340 6712	2·935 381	0·946 5789	45
16	·318 4079	·335 8896	·977 168	·947 9538	·322 5411	·340 7524	·934 682	·946 5555	44
17	·318 4768	·335 9706	·976 451	·947 9307	·322 6099	·340 8336	·933 983	·946 5320	43
18	·318 5457	·336 0515	·975 734	·947 9075	·322 6787	·340 9147	·933 285	·946 5086	42
19	·318 6147	·336 1324	·975 018	·947 8843	·322 7475	·340 9959	·932 586	·946 4851	41
20	0·318 6836	0·336 2134	2·974 302	0·947 8612	0·322 8164	0·341 0771	2·931 888	0·946 4616	40
21	·318 7525	·336 2943	·973 586	·947 8380	·322 8852	·341 1583	·931 191	·946 4381	39
22	·318 8215	·336 3753	·972 870	·947 8148	·322 9540	·341 2395	·930 493	·946 4147	38
23	·318 8904	·336 4562	·972 155	·947 7916	·323 0229	·341 3207	·929 796	·946 3912	37
24	·318 9593	·336 5372	·971 440	·947 7684	·323 0917	·341 4019	·929 099	·946 3677	36
25	0·319 0282	0·336 6181	2·970 725	0·947 7452	0·323 1605	0·341 4831	2·928 403	0·946 3442	35
26	·319 0972	·336 6991	·970 011	·947 7220	·323 2293	·341 5643	·927 707	·946 3207	34
27	·319 1661	·336 7801	·969 297	·947 6988	·323 2981	·341 6455	·927 011	·946 2972	33
28	·319 2350	·336 8610	·968 583	·947 6756	·323 3670	·341 7267	·926 315	·946 2736	32
29	·319 3039	·336 9420	·967 870	·947 6524	·323 4358	·341 8079	·925 620	·946 2501	31
30	0·319 3728	0·337 0230	2·967 157	0·947 6291	0·323 5046	0·341 8891	2·924 925	0·946 2266	30
31	·319 4417	·337 1040	·966 444	·947 6059	·323 5734	·341 9703	·924 230	·946 2031	29
32	·319 5106	·337 1850	·965 731	·947 5827	·323 6422	·342 0516	·923 536	·946 1795	28
33	·319 5796	·337 2660	·965 019	·947 5594	·323 7110	·342 1328	·922 842	·946 1560	27
34	·319 6485	·337 3470	·964 307	·947 5362	·323 7798	·342 2140	·922 148	·946 1325	26
35	0·319 7174	0·337 4280	2·963 596	0·947 5130	0·323 8486	0·342 2953	2·921 454	0·946 1089	25
36	·319 7863	·337 5090	·962 884	·947 4897	·323 9174	·342 3765	·920 761	·946 0854	24
37	·319 8552	·337 5900	·962 173	·947 4664	·323 9862	·342 4578	·920 068	·946 0618	23
38	·319 9241	·337 6710	·961 463	·947 4432	·324 0550	·342 5390	·919 375	·946 0382	22
39	·319 9930	·337 7520	·960 752	·947 4199	·324 1238	·342 6203	·918 683	·946 0147	21
40	0·320 0619	0·337 8330	2·960 042	0·947 3966	0·324 1926	0·342 7015	2·917 991	0·945 9911	20
41	·320 1308	·337 9140	·959 332	·947 3734	·324 2614	·342 7828	·917 299	·945 9675	19
42	·320 1997	·337 9951	·958 623	·947 3501	·324 3302	·342 8641	·916 608	·945 9439	18
43	·320 2686	·338 0761	·957 914	·947 3268	·324 3990	·342 9454	·915 916	·945 9203	17
44	·320 3374	·338 1571	·957 205	·947 3035	·324 4678	·343 0266	·915 226	·945 8968	16
45	0·320 4063	0·338 2382	2·956 496	0·947 2802	0·324 5366	0·343 1079	2·914 535	0·945 8732	15
46	·320 4752	·338 3192	·955 788	·947 2569	·324 6053	·343 1892	·913 845	·945 8495	14
47	·320 5441	·338 4003	·955 080	·947 2336	·324 6741	·343 2705	·913 155	·945 8259	1
48	·320 6130	·338 4813	·954 373	·947 2103	·324 7429	·343 3518	·912 465	·945 8023	1
49	·320 6819	·338 5624	·953 665	·947 1870	·324 8117	·343 4331	·911 775	·945 7787	1
50	0·320 7508	0·338 6434	2·952 958	0·947 1636	0·324 8805	0·343 5144	2·911 086	0·945 7551	1
51	·320 8196	·338 7245	·952 252	·947 1403	·324 9492	·343 5957	·910 397	·945 7315	0
52	·320 8885	·338 8056	·951 545	·947 1170	·325 0180	·343 6770	·909 709	·945 7078	0
53	·320 9574	·338 8866	·950 839	·947 0936	·325 0868	·343 7583	·909 021	·945 6842	0
54	·321 0263	·338 9677	·950 133	·947 0703	·325 1556	·343 8396	·908 333	·945 6605	0
55	0·321 0951	0·339 0488	2·949 428	0·947 0469	0·325 2243	0·343 9209	2·907 645	0·945 6369	05
56	·321 1640	·339 1299	·948 723	·947 0236	·325 2931	·344 0023	·906 958	·945 6132	0
57	·321 2329	·339 2110	·948 018	·947 0002	·325 3619	·344 0836	·906 270	·945 5896	0
58	·321 3017	·339 2921	·947 313	·946 9769	·325 4306	·344 1649	·905 584	·945 5659	0
59	·321 3706	·339 3732	·946 609	·946 9535	·325 4994	·344 2463	·904 897	·945 5422	0
60	0·321 4395	0·339 4543	2·945 905	0·946 9301	0·325 5682	0·344 3276	2·904 211	0·945 5186	0
	cos	cot	tan	sin	cos	cot	tan	sin	
d	688–690	811–808	704–722	234–231	687–689	814–811	686–704	237–233	d
	$4^{h}\ 45^{m}$				$4^{h}\ 44^{m}$				

$1^{h}\ 16^{m}$ $1^{h}\ 17^{m}$

d	688–686	813–816	686–669	237–240	687–685	816–819	669–653	239–243	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·325 5682	0·344 3276	2·904 211	0·945 5186	0·329 6906	0·349 2156	2·863 560	0·944 0890	60
01	·325 6369	·344 4090	·903 525	·945 4949	·329 7593	·349 2972	·862 891	·944 0650	59
02	·325 7057	·344 4903	·902 839	·945 4712	·329 8280	·349 3788	·862 223	·944 0411	58
03	·325 7744	·344 5717	·902 154	·945 4475	·329 8966	·349 4604	·861 554	·944 0171	57
04	·325 8432	·344 6530	·901 469	·945 4238	·329 9653	·349 5420	·860 886	·943 9931	56
05	0·325 9119	0·344 7344	2·900 784	0·945 4001	0·330 0339	0·349 6236	2·860 219	0·943 9691	55
06	·325 9807	·344 8158	·900 100	·945 3764	·330 1026	·349 7053	·859 551	·943 9451	54
07	·326 0494	·344 8971	·899 415	·945 3527	·330 1712	·349 7869	·858 884	·943 9211	53
08	·326 1182	·344 9785	·898 731	·945 3290	·330 2398	·349 8685	·858 217	·943 8971	52
09	·326 1869	·345 0599	·898 048	·945 3053	·330 3085	·349 9501	·857 550	·943 8730	51
10	0·326 2557	0·345 1413	2·897 364	0·945 2816	0·330 3771	0·350 0317	2·856 884	0·943 8490	50
11	·326 3244	·345 2226	·896 681	·945 2578	·330 4458	·350 1134	·856 218	·943 8250	49
12	·326 3932	·345 3040	·895 999	·945 2341	·330 5144	·350 1950	·855 552	·943 8010	48
13	·326 4619	·345 3854	·895 316	·945 2104	·330 5830	·350 2767	·854 886	·943 7769	47
14	·326 5306	·345 4668	·894 634	·945 1866	·330 6517	·350 3583	·854 221	·943 7529	46
15	0·326 5994	0·345 5482	2·893 952	0·945 1629	0·330 7203	0·350 4400	2·853 556	0·943 7288	45
16	·326 6681	·345 6296	·893 270	·945 1391	·330 7889	·350 5216	·852 891	·943 7048	44
17	·326 7368	·345 7111	·892 589	·945 1154	·330 8575	·350 6033	·852 227	·943 6807	43
18	·326 8056	·345 7925	·891 908	·945 0916	·330 9262	·350 6849	·851 562	·943 6566	42
19	·326 8743	·345 8739	·891 227	·945 0678	·330 9948	·350 7666	·850 899	·943 6326	41
20	0·326 9430	0·345 9553	2·890 547	0·945 0441	0·331 0634	0·350 8483	2·850 235	0·943 6085	40
21	·327 0117	·346 0367	·889 867	·945 0203	·331 1320	·350 9300	·849 572	·943 5844	39
22	·327 0805	·346 1182	·889 187	·944 9965	·331 2007	·351 0116	·848 908	·943 5603	38
23	·327 1492	·346 1996	·888 507	·944 9727	·331 2693	·351 0933	·848 246	·943 5363	37
24	·327 2179	·346 2810	·887 828	·944 9489	·331 3379	·351 1750	·847 583	·943 5122	36
25	0·327 2866	0·346 3625	2·887 149	0·944 9251	0·331 4065	0·351 2567	2·846 921	0·943 4881	35
26	·327 3553	·346 4439	·886 470	·944 9013	·331 4751	·351 3384	·846 259	·943 4640	34
27	·327 4240	·346 5254	·885 791	·944 8775	·331 5437	·351 4201	·845 597	·943 4399	33
28	·327 4928	·346 6068	·885 113	·944 8537	·331 6123	·351 5018	·844 936	·943 4157	32
29	·327 5615	·346 6883	·884 435	·944 8299	·331 6809	·351 5835	·844 274	·943 3916	31
30	0·327 6302	0·346 7698	2·883 758	0·944 8060	0·331 7495	0·351 6652	2·843 614	0·943 3675	30
31	·327 6989	·346 8512	·883 080	·944 7822	·331 8181	·351 7469	·842 953	·943 3434	29
32	·327 7676	·346 9327	·882 403	·944 7584	·331 8867	·351 8287	·842 293	·943 3192	28
33	·327 8363	·347 0142	·881 727	·944 7345	·331 9553	·351 9104	·841 633	·943 2951	27
34	·327 9050	·347 0957	·881 050	·944 7107	·332 0239	·351 9921	·840 973	·943 2710	26
35	0·327 9737	0·347 1772	2·880 374	0·944 6869	0·332 0925	0·352 0739	2·840 313	0·943 2468	25
36	·328 0424	·347 2586	·879 698	·944 6630	·332 1611	·352 1556	·839 654	·943 2227	24
37	·328 1111	·347 3401	·879 022	·944 6391	·332 2297	·352 2373	·838 995	·943 1985	23
38	·328 1798	·347 4216	·878 347	·944 6153	·332 2983	·352 3191	·838 336	·943 1743	22
39	·328 2485	·347 5031	·877 672	·944 5914	·332 3669	·352 4008	·837 678	·943 1502	21
40	0·328 3172	0·347 5846	2·876 997	0·944 5675	0·332 4355	0·352 4826	2·837 020	0·943 1260	20
41	·328 3859	·347 6662	·876 323	·944 5437	·332 5041	·352 5643	·836 362	·943 1018	19
42	·328 4546	·347 7477	·875 648	·944 5198	·332 5727	·352 6461	·835 704	·943 0776	18
43	·328 5232	·347 8292	·874 974	·944 4959	·332 6412	·352 7279	·835 047	·943 0534	17
44	·328 5919	·347 9107	·874 301	·944 4720	·332 7098	·352 8096	·834 390	·943 0293	16
45	0·328 6606	0·347 9922	2·873 627	0·944 4481	0·332 7784	0·352 8914	2·833 733	0·943 0051	15
46	·328 7293	·348 0738	·872 954	·944 4242	·332 8470	·352 9732	·833 076	·942 9809	14
47	·328 7980	·348 1553	·872 281	·944 4003	·332 9155	·353 0550	·832 420	·942 9566	13
48	·328 8666	·348 2368	·871 609	·944 3764	·332 9841	·353 1368	·831 764	·942 9324	12
49	·328 9353	·348 3184	·870 937	·944 3525	·333 0527	·353 2186	·831 108	·942 9082	11
50	0·329 0040	0·348 3999	2·870 265	0·944 3285	0·333 1213	0·353 3004	2·830 453	0·942 8840	10
51	·329 0727	·348 4815	·869 593	·944 3046	·333 1898	·353 3822	·829 798	·942 8598	09
52	·329 1413	·348 5630	·868 921	·944 2807	·333 2584	·353 4640	·829 143	·942 8355	08
53	·329 2100	·348 6446	·868 250	·944 2567	·333 3270	·353 5458	·828 488	·942 8113	07
54	·329 2787	·348 7262	·867 580	·944 2328	·333 3955	·353 6276	·827 834	·942 7871	06
55	0·329 3473	0·348 8077	2·866 909	0·944 2088	0·333 4641	0·353 7094	2·827 179	0·942 7628	05
56	·329 4160	·348 8893	·866 239	·944 1849	·333 5326	·353 7912	·826 526	·942 7386	04
57	·329 4847	·348 9709	·865 569	·944 1609	·333 6012	·353 8731	·825 872	·942 7143	03
58	·329 5533	·349 0525	·864 899	·944 1370	·333 6698	·353 9549	·825 219	·942 6900	02
59	·329 6220	·349 1340	·864 229	·944 1130	·333 7383	·354 0367	·824 566	·942 6658	01
60	0·329 6906	0·349 2156	2·863 560	0·944 0890	0·333 8069	0·354 1186	2·823 913	0·942 6415	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	686–688	816–813	669–686	240–237	685–687	819–816	653–669	243–239	d

$4^{h}\ 43^{m}$ $4^{h}\ 42^{m}$

$1^{h}\ 18^{m}$ $1^{h}\ 19^{m}$

d	686–684	818–821	653–637	242–246	685–683	821–824	637–622	245–249	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·333 8069	0·354 1186	2·823 913	0·942 6415	0·337 9167	0·359 0367	2·785 231	0·941 1760	60
01	·333 8754	·354 2004	·823 260	·942 6172	·337 9852	·359 1188	·784 594	·941 1514	59
02	·333 9440	·354 2823	·822 608	·942 5929	·338 0536	·359 2009	·783 957	·941 1269	58
03	·334 0125	·354 3641	·821 956	·942 5686	·338 1220	·359 2830	·783 321	·941 1023	57
04	·334 0810	·354 4460	·821 304	·942 5444	·338 1905	·359 3651	·782 685	·941 0777	56
05	0·334 1496	0·354 5278	2·820 653	0·942 5201	0·338 2589	0·359 4472	2·782 050	0·941 0531	55
06	·334 2181	·354 6097	·820 002	·942 4958	·338 3274	·359 5293	·781 414	·941 0285	54
07	·334 2867	·354 6916	·819 351	·942 4714	·338 3958	·359 6115	·780 779	·941 0039	53
08	·334 3552	·354 7734	·818 700	·942 4471	·338 4642	·359 6936	·780 144	·940 9793	52
09	·334 4237	·354 8553	·818 050	·942 4228	·338 5326	·359 7757	·779 509	·940 9546	51
10	0·334 4923	0·354 9372	2·817 400	0·942 3985	0·338 6011	0·359 8579	2·778 875	0·940 9300	50
11	·334 5608	·355 0191	·816 750	·942 3742	·338 6695	·359 9400	·778 241	·940 9054	49
12	·334 6293	·355 1010	·816 100	·942 3498	·338 7379	·360 0222	·777 607	·940 8808	48
13	·334 6979	·355 1829	·815 451	·942 3255	·338 8063	·360 1043	·776 973	·940 8561	47
14	·334 7664	·355 2648	·814 802	·942 3012	·338 8748	·360 1865	·776 340	·940 8315	46
15	0·334 8349	0·355 3467	2·814 153	0·942 2768	0·338 9432	0·360 2686	2·775 707	0·940 8068	45
16	·334 9034	·355 4286	·813 505	·942 2525	·339 0116	·360 3508	·775 074	·940 7822	44
17	·334 9720	·355 5105	·812 857	·942 2281	·339 0800	·360 4329	·774 441	·940 7575	43
18	·335 0405	·355 5924	·812 209	·942 2037	·339 1484	·360 5151	·773 809	·940 7329	42
19	·335 1090	·355 6743	·811 561	·942 1794	·339 2168	·360 5973	·773 177	·940 7082	41
20	0·335 1775	0·355 7562	2·810 913	0·942 1550	0·339 2852	0·360 6795	2·772 545	0·940 6835	40
21	·335 2460	·355 8382	·810 266	·942 1306	·339 3537	·360 7617	·771 913	·940 6589	39
22	·335 3145	·355 9201	·809 619	·942 1062	·339 4221	·360 8438	·771 282	·940 6342	38
23	·335 3831	·356 0020	·808 973	·942 0818	·339 4905	·360 9260	·770 651	·940 6095	37
24	·335 4516	·356 0840	·808 326	·942 0575	·339 5589	·361 0082	·770 020	·940 5848	36
25	0·335 5201	0·356 1659	2·807 680	0·942 0331	0·339 6273	0·361 0904	2·769 389	0·940 5601	35
26	·335 5886	·356 2479	·807 034	·942 0087	·339 6957	·361 1726	·768 759	·940 5354	34
27	·335 6571	·356 3298	·806 389	·941 9842	·339 7641	·361 2549	·768 129	·940 5107	33
28	·335 7256	·356 4118	·805 743	·941 9598	·339 8325	·361 3371	·767 499	·940 4860	32
29	·335 7941	·356 4938	·805 098	·941 9354	·339 9008	·361 4193	·766 869	·940 4613	31
30	0·335 8626	0·356 5757	2·804 453	0·941 9110	0·339 9692	0·361 5015	2·766 240	0·940 4366	30
31	·335 9311	·356 6577	·803 809	·941 8866	·340 0376	·361 5837	·765 611	·940 4118	29
32	·335 9996	·356 7397	·803 165	·941 8621	·340 1060	·361 6660	·764 982	·940 3871	28
33	·336 0681	·356 8216	·802 521	·941 8377	·340 1744	·361 7482	·764 354	·940 3624	27
34	·336 1366	·356 9036	·801 877	·941 8133	·340 2428	·361 8305	·763 725	·940 3376	26
35	0·336 2051	0·356 9856	2·801 233	0·941 7888	0·340 3112	0·361 9127	2·763 097	0·940 3129	25
36	·336 2735	·357 0676	·800 590	·941 7644	·340 3796	·361 9949	·762 470	·940 2881	24
37	·336 3420	·357 1496	·799 947	·941 7399	·340 4479	·362 0772	·761 842	·940 2634	23
38	·336 4105	·357 2316	·799 304	·941 7154	·340 5163	·362 1595	·761 215	·940 2386	22
39	·336 4790	·357 3136	·798 662	·941 6910	·340 5847	·362 2417	·760 588	·940 2138	21
40	0·336 5475	0·357 3956	2·798 020	0·941 6665	0·340 6531	0·362 3240	2·759 961	0·940 1891	20
41	·336 6160	·357 4776	·797 378	·941 6420	·340 7214	·362 4063	·759 334	·940 1643	19
42	·336 6844	·357 5596	·796 736	·941 6175	·340 7898	·362 4885	·758 708	·940 1395	18
43	·336 7529	·357 6417	·796 095	·941 5931	·340 8582	·362 5708	·758 082	·940 1147	17
44	·336 8214	·357 7237	·795 454	·941 5686	·340 9265	·362 6531	·757 456	·940 0899	16
45	0·336 8899	0·357 8057	2·794 813	0·941 5441	0·340 9949	0·362 7354	2·756 831	0·940 0651	15
46	·336 9583	·357 8878	·794 172	·941 5196	·341 0633	·362 8177	·756 205	·940 0403	14
47	·337 0268	·357 9698	·793 532	·941 4951	·341 1316	·362 9000	·755 580	·940 0155	13
48	·337 0953	·358 0518	·792 892	·941 4705	·341 2000	·362 9823	·754 955	·939 9907	12
49	·337 1637	·358 1339	·792 252	·941 4460	·341 2683	·363 0646	·754 331	·939 9659	11
50	0·337 2322	0·358 2159	2·791 612	0·941 4215	0·341 3367	0·363 1469	2·753 707	0·939 9411	10
51	·337 3006	·358 2980	·790 973	·941 3970	·341 4050	·363 2292	·753 083	·939 9163	09
52	·337 3691	·358 3801	·790 334	·941 3724	·341 4734	·363 3115	·752 459	·939 8914	08
53	·337 4376	·358 4621	·789 695	·941 3479	·341 5417	·363 3939	·751 835	·939 8666	07
54	·337 5060	·358 5442	·789 057	·941 3234	·341 6101	·363 4762	·751 212	·939 8418	06
55	0·337 5745	0·358 6263	2·788 418	0·941 2988	0·341 6784	0·363 5585	2·750 589	0·939 8169	05
56	·337 6429	·358 7083	·787 780	·941 2743	·341 7468	·363 6408	·749 966	·939 7921	04
57	·337 7114	·358 7904	·787 142	·941 2497	·341 8151	·363 7232	·749 344	·939 7672	03
58	·337 7798	·358 8725	·786 505	·941 2252	·341 8835	·363 8055	·748 721	·939 7424	02
59	·337 8483	·358 9546	·785 868	·941 2006	·341 9518	·363 8879	·748 099	·939 7175	01
60	0·337 9167	0·359 0367	2·785 231	0·941 1760	0·342 0201	0·363 9702	2·747 477	0·939 6926	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	684–686	821–818	637–653	246–242	683–685	824–821	622–637	249–245	d

$4^{h}\ 41^{m}$ $4^{h}\ 40^{m}$

$1^h\ 20^m$ $1^h\ 21^m$

d	684–682	823–827	621–607	248–252	683–681	826–829	607–593	251–255	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·342 0201	0·363 9702	2·747 477	0·939 6926	0·346 1171	0·368 9195	2·710 619	0·938 1913	60
01	·342 0885	·364 0526	·746 856	·939 6677	·346 1853	·369 0021	·710 012	·938 1662	59
02	·342 1568	·364 1350	·746 235	·939 6429	·346 2535	·369 0847	·709 405	·938 1410	58
03	·342 2251	·364 2173	·745 614	·939 6180	·346 3217	·369 1674	·708 799	·938 1158	57
04	·342 2935	·364 2997	·744 993	·939 5931	·346 3900	·369 2500	·708 192	·938 0906	56
05	0·342 3618	0·364 3821	2·744 372	0·939 5682	0·346 4582	0·369 3326	2·707 586	0·938 0654	55
06	·342 4301	·364 4644	·743 752	·939 5433	·346 5264	·369 4153	·706 981	·938 0402	54
07	·342 4985	·364 5468	·743 132	·939 5184	·346 5946	·369 4979	·706 375	·938 0150	53
08	·342 5668	·364 6292	·742 512	·939 4935	·346 6628	·369 5806	·705 770	·937 9898	52
09	·342 6351	·364 7116	·741 892	·939 4686	·346 7310	·369 6632	·705 165	·937 9646	51
10	0·342 7034	0·364 7940	2·741 273	0·939 4436	0·346 7992	0·369 7459	2·704 560	0·937 9394	50
11	·342 7717	·364 8764	·740 654	·939 4187	·346 8674	·369 8286	·703 956	·937 9142	49
12	·342 8400	·364 9588	·740 035	·939 3938	·346 9357	·369 9112	·703 351	·937 8889	48
13	·342 9084	·365 0412	·739 417	·939 3689	·347 0039	·369 9939	·702 747	·937 8637	47
14	·342 9767	·365 1236	·738 798	·939 3439	·347 0721	·370 0766	·702 143	·937 8385	46
15	0·343 0450	0·365 2061	2·738 180	0·939 3190	0·347 1403	0·370 1593	2·701 540	0·937 8132	45
16	·343 1133	·365 2885	·737 562	·939 2940	·347 2085	·370 2420	·700 936	·937 7880	44
17	·343 1816	·365 3709	·736 945	·939 2691	·347 2767	·370 3247	·700 333	·937 7627	43
18	·343 2499	·365 4533	·736 327	·939 2441	·347 3448	·370 4073	·699 730	·937 7375	42
19	·343 3182	·365 5358	·735 710	·939 2191	·347 4130	·370 4901	·699 128	·937 7122	41
20	0·343 3865	0·365 6182	2·735 093	0·939 1942	0·347 4812	0·370 5728	2·698 525	0·937 6869	40
21	·343 4548	·365 7007	·734 477	·939 1692	·347 5494	·370 6555	·697 923	·937 6617	39
22	·343 5231	·365 7831	·733 860	·939 1442	·347 6176	·370 7382	·697 321	·937 6364	38
23	·343 5914	·365 8656	·733 244	·939 1192	·347 6858	·370 8209	·696 720	·937 6111	37
24	·343 6597	·365 9480	·732 628	·939 0943	·347 7540	·370 9036	·696 118	·937 5858	36
25	0·343 7280	0·366 0305	2·732 013	0·939 0693	0·347 8222	0·370 9864	2·695 517	0·937 5605	35
26	·343 7963	·366 1130	·731 397	·939 0443	·347 8903	·371 0691	·694 916	·937 5352	34
27	·343 8646	·366 1954	·730 782	·939 0193	·347 9585	·371 1518	·694 315	·937 5099	33
28	·343 9329	·366 2779	·730 167	·938 9942	·348 0267	·371 2346	·693 715	·937 4846	32
29	·344 0011	·366 3604	·729 553	·938 9692	·348 0949	·371 3173	·693 114	·937 4593	31
30	0·344 0694	0·366 4429	2·728 938	0·938 9442	0·348 1630	0·371 4001	2·692 514	0·937 4340	30
31	·344 1377	·366 5254	·728 324	·938 9192	·348 2312	·371 4828	·691 915	·937 4087	29
32	·344 2060	·366 6079	·727 710	·938 8942	·348 2994	·371 5656	·691 315	·937 3833	28
33	·344 2743	·366 6904	·727 097	·938 8691	·348 3676	·371 6483	·690 716	·937 3580	27
34	·344 3425	·366 7729	·726 483	·938 8441	·348 4357	·371 7311	·690 116	·937 3327	26
35	0·344 4108	0·366 8554	2·725 870	0·938 8190	0·348 5039	0·371 8139	2·689 518	0·937 3073	25
36	·344 4791	·366 9379	·725 257	·938 7940	·348 5720	·371 8967	·688 919	·937 2820	24
37	·344 5473	·367 0204	·724 644	·938 7689	·348 6402	·371 9794	·688 321	·937 2566	23
38	·344 6156	·367 1029	·724 032	·938 7439	·348 7084	·372 0622	·687 722	·937 2313	22
39	·344 6839	·367 1854	·723 420	·938 7188	·348 7765	·372 1450	·687 124	·937 2059	21
40	0·344 7521	0·367 2680	2·722 808	0·938 6938	0·348 8447	0·372 2278	2·686 527	0·937 1806	20
41	·344 8204	·367 3505	·722 196	·938 6687	·348 9128	·372 3106	·685 929	·937 1552	19
42	·344 8887	·367 4330	·721 584	·938 6436	·348 9810	·372 3934	·685 332	·937 1298	18
43	·344 9569	·367 5156	·720 973	·938 6185	·349 0491	·372 4762	·684 735	·937 1044	17
44	·345 0252	·367 5981	·720 362	·938 5934	·349 1173	·372 5590	·684 138	·937 0790	16
45	0·345 0934	0·367 6807	2·719 751	0·938 5683	0·349 1854	0·372 6419	2·683 542	0·937 0536	15
46	·345 1617	·367 7632	·719 141	·938 5432	·349 2536	·372 7247	·682 945	·937 0283	14
47	·345 2299	·367 8458	·718 530	·938 5181	·349 3217	·372 8075	·682 349	·937 0029	13
48	·345 2982	·367 9284	·717 920	·938 4930	·349 3898	·372 8903	·681 754	·936 9774	12
49	·345 3664	·368 0109	·717 311	·938 4679	·349 4580	·372 9732	·681 158	·936 9520	11
50	0·345 4347	0·368 0935	2·716 701	0·938 4428	0·349 5261	0·373 0560	2·680 563	0·936 9266	10
51	·345 5029	·368 1761	·716 092	·938 4177	·349 5943	·373 1389	·679 967	·936 9012	09
52	·345 5712	·368 2587	·715 483	·938 3925	·349 6624	·373 2217	·679 372	·936 8758	08
53	·345 6394	·368 3412	·714 874	·938 3674	·349 7305	·373 3046	·678 778	·936 8503	07
54	·345 7077	·368 4238	·714 265	·938 3423	·349 7986	·373 3874	·678 183	·936 8249	06
55	0·345 7759	0·368 5064	2·713 657	0·938 3171	0·349 8668	0·373 4703	2·677 589	0·936 7995	05
56	·345 8441	·368 5890	·713 049	·938 2920	·349 9349	·373 5532	·676 995	·936 7740	04
57	·345 9124	·368 6716	·712 441	·938 2668	·350 0030	·373 6360	·676 401	·936 7486	03
58	·345 9806	·368 7542	·711 833	·938 2417	·350 0711	·373 7189	·675 808	·936 7231	02
59	·346 0488	·368 8369	·711 226	·938 2165	·350 1393	·373 8018	·675 215	·936 6977	01
60	0·346 1171	0·368 9195	2·710 619	0·938 1913	0·350 2074	0·373 8847	2·674 621	0·936 6722	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	682–684	827–823	607–621	252–248	681–683	829–826	593–607	255–251	d

$4^h\ 39^m$ $4^h\ 38^m$

1^h 22^m 1^h 23^m

d	682–680	829–832	593–579	254–258	680–678	831–835	579–566	257–261	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·350 2074	0·373 8847	2·674 621	0·936 6722	0·354 2910	0·378 8661	2·639 455	0·935 1352	60
01	·350 2755	·373 9676	·674 029	·936 6467	·354 3590	·378 9493	·638 876	·935 1094	59
02	·350 3436	·374 0505	·673 436	·936 6212	·354 4270	·379 0324	·638 297	·935 0837	58
03	·350 4117	·374 1334	·672 844	·936 5958	·354 4950	·379 1156	·637 718	·935 0579	57
04	·350 4798	·374 2163	·672 252	·936 5703	·354 5630	·379 1988	·637 139	·935 0321	56
05	0·350 5479	0·374 2992	2·671 660	0·936 5448	0·354 6310	0·379 2820	2·636 561	0·935 0063	55
06	·350 6160	·374 3821	·671 068	·936 5193	·354 6990	·379 3652	·635 983	·934 9805	54
07	·350 6842	·374 4650	·670 477	·936 4938	·354 7670	·379 4483	·635 405	·934 9547	53
08	·350 7523	·374 5479	·669 885	·936 4683	·354 8350	·379 5315	·634 827	·934 9289	52
09	·350 8204	·374 6309	·669 294	·936 4428	·354 9030	·379 6147	·634 250	·934 9031	51
10	0·350 8885	0·374 7138	2·668 704	0·936 4173	0·354 9710	0·379 6979	2·633 672	0·934 8773	50
11	·350 9566	·374 7967	·668 113	·936 3917	·355 0390	·379 7812	·633 095	·934 8515	49
12	·351 0246	·374 8797	·667 523	·936 3662	·355 1070	·379 8644	·632 519	·934 8257	48
13	·351 0927	·374 9626	·666 933	·936 3407	·355 1749	·379 9476	·631 942	934 7998	47
14	·351 1608	·375 0456	·666 343	·936 3152	·355 2429	·380 0308	·631 366	·934 7740	46
15	0·351 2289	0·375 1285	2·665 753	0·936 2896	0·355 3109	0·380 1140	2·630 789	0·934 7482	45
16	·351 2970	·375 2115	·665 164	·936 2641	·355 3789	·380 1973	·630 214	·934 7223	44
17	·351 3651	·375 2944	·664 575	·936 2385	·355 4469	·380 2805	·629 638	·934 6965	43
18	·351 4332	·375 3774	·663 986	·936 2130	·355 5148	·380 3637	·629 062	·934 6706	42
19	·351 5013	·375 4604	·663 397	·936 1874	·355 5828	·380 4470	·628 487	·934 6448	41
20	0·351 5693	0·375 5433	2·662 809	0·936 1618	0·355 6508	0·380 5302	2·627 912	0·934 6189	40
21	·351 6374	·375 6263	·662 220	·936 1363	·355 7187	·380 6135	·627 337	·934 5931	39
22	·351 7055	·375 7093	·661 632	·936 1107	·355 7867	·380 6968	·626 763	·934 5672	38
23	·351 7736	·375 7923	·661 044	·936 0851	·355 8547	·380 7800	·626 188	·934 5413	37
24	·351 8416	·375 8753	·660 457	·936 0595	·355 9226	·380 8633	·625 614	·934 5154	36
25	0·351 9097	0·375 9583	2·659 870	0·936 0339	0·355 9906	0·380 9466	2·625 040	0·934 4895	35
26	·351 9778	·376 0413	·659 282	·936 0084	·356 0585	·381 0298	·624 466	·934 4637	34
27	·352 0459	·376 1243	·658 696	·935 9828	·356 1265	·381 1131	·623 893	·934 4378	33
28	·352 1139	·376 2073	·658 109	·935 9571	·356 1944	·381 1964	·623 320	·934 4119	32
29	·352 1820	·376 2903	·657 522	·935 9315	·356 2624	·381 2797	·622 747	·934 3860	31
30	0·352 2500	0·376 3733	2·656 936	0·935 9059	0·356 3303	0·381 3630	2·622 174	0·934 3600	30
31	·352 3181	·376 4564	·656 350	·935 8803	·356 3983	·381 4463	·621 601	·934 3341	29
32	·352 3862	·376 5394	·655 765	·935 8547	·356 4662	·381 5296	·621 029	·934 3082	28
33	·352 4542	·376 6224	·655 179	·935 8291	·356 5342	·381 6129	·620 456	·934 2823	27
34	·352 5223	·376 7055	·654 594	·935 8034	·356 6021	·381 6962	·619 884	·934 2563	26
35	0·352 5903	0·376 7885	2·654 009	0·935 7778	0·356 6701	0·381 7795	2·619 313	0·934 2304	25
36	·352 6584	·376 8716	·653 424	·935 7521	·356 7380	·381 8629	·618 741	·934 2045	24
37	·352 7264	·376 9546	·652 839	·935 7265	·356 8059	·381 9462	·618 170	·934 1785	23
38	·352 7945	·377 0377	·652 255	·935 7008	·356 8739	·382 0295	·617 599	·934 1526	22
39	·352 8625	·377 1207	·651 671	·935 6752	·356 9418	·382 1129	·617 028	·934 1266	21
40	0·352 9306	0·377 2038	2·651 087	0·935 6495	0·357 0097	0·382 1962	2·616 457	0·934 1007	20
41	·352 9986	·377 2869	·650 503	·935 6238	·357 0777	·382 2796	·615 887	·934 0747	19
42	·353 0666	·377 3700	·649 919	·935 5982	·357 1456	·382 3629	·615 316	·934 0487	18
43	·353 1347	·377 4530	·649 336	·935 5725	·357 2135	·382 4463	·614 746	·934 0228	17
44	·353 2027	·377 5361	·648 753	·935 5468	·357 2814	·382 5296	·614 177	·933 9968	16
45	0·353 2708	0·377 6192	2·648 170	0·935 5211	0·357 3494	0·382 6130	2·613 607	0·933 9708	15
46	·353 3388	·377 7023	·647 588	·935 4954	·357 4173	·382 6964	·613 038	·933 9448	14
47	·353 4068	·377 7854	·647 005	·935 4697	·357 4852	·382 7797	·612 468	·933 9188	13
48	·353 4748	·377 8685	·646 423	·935 4440	·357 5531	·382 8631	·611 900	·933 8928	12
49	·353 5429	·377 9516	·645 841	·935 4183	·357 6210	·382 9465	·611 331	·933 8668	11
50	0·353 6109	0·378 0347	2·645 260	0·935 3926	0·357 6889	0·383 0299	2·610 762	0·933 8408	10
51	·353 6789	·378 1178	·644 678	·935 3669	·357 7568	·383 1133	·610 194	·933 8148	09
52	·353 7469	·378 2010	·644 097	·935 3412	·357 8248	·383 1967	·609 626	·933 7888	08
53	·353 8150	·378 2841	·643 516	·935 3154	·357 8927	·383 2801	·609 058	·933 7627	07
54	·353 8830	·378 3672	·642 935	·935 2897	·357 9606	·383 3635	·608 490	·933 7367	06
55	0·353 9510	0·378 4504	2·642 354	0·935 2640	0·358 0285	0·383 4469	2·607 923	0·933 7107	05
56	·354 0190	·378 5335	·641 774	·935 2382	·358 0964	·383 5303	·607 356	·933 6846	04
57	·354 0870	·378 6166	·641 194	·935 2125	·358 1643	·383 6137	·606 789	·933 6586	03
58	·354 1550	·378 6998	·640 614	·935 1867	·358 2322	·383 6972	·606 222	·933 6325	02
59	·354 2230	·378 7830	·640 034	·935 1610	·358 3001	·383 7806	·605 655	·933 6065	01
60	0·354 2910	0·378 8661	2·639 455	0·935 1352	0·358 3679	0·383 8640	2·605 089	0·933 5804	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	680–682	832–829	579–593	258–254	678–680	835–831	566–579	261–257	d

4^h 37^m 4^h 36^m

$1^{h}\ 24^{m}$ $1^{h}\ 25^{m}$

d	679–677	834–837	566–553	260–264	678–676	837–840	554–541	263–267	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·358 3679	0·383 8640	2·605 089	0·933 5804	0·362 4380	0·388 8787	2·571 496	0·932 0079	60
01	·358 4358	·383 9475	·604 523	·933 5544	·362 5058	·388 9625	·570 942	·931 9815	59
02	·358 5037	·384 0309	·603 957	·933 5283	·362 5736	·389 0462	·570 389	·931 9551	58
03	·358 5716	·384 1144	·603 391	·933 5022	·362 6414	·389 1299	·569 836	·931 9288	57
04	·358 6395	·384 1978	·602 826	·933 4761	·362 7091	·389 2136	·569 283	·931 9024	56
05	0·358 7074	0·384 2813	2·602 260	0·933 4501	0·362 7769	0·389 2974	2·568 730	0·931 8760	55
06	·358 7753	·384 3647	·601 695	·933 4240	·362 8447	·389 3811	·568 178	·931 8496	54
07	·358 8431	·384 4482	·601 131	·933 3979	·362 9124	·389 4649	·567 626	·931 8232	53
08	·358 9110	·384 5317	·600 566	·933 3718	·362 9802	·389 5486	·567 074	·931 7969	52
09	·358 9789	·384 6152	·600 001	·933 3457	·363 0480	·389 6324	·566 522	·931 7705	51
10	0·359 0468	0·384 6986	2·599 437	0·933 3196	0·363 1157	0·389 7162	2·565 970	0·931 7441	50
11	·359 1146	·384 7821	·598 873	·933 2935	·363 1835	·389 7999	·565 419	·931 7176	49
12	·359 1825	·384 8656	·598 309	·933 2673	·363 2512	·389 8837	·564 867	·931 6912	48
13	·359 2504	·384 9491	·597 746	·933 2412	·363 3190	·389 9675	·564 316	·931 6648	47
14	·359 3183	·385 0326	·597 183	·933 2151	·363 3867	·390 0513	·563 766	·931 6384	46
15	0·359 3861	0·385 1161	2·596 619	0·933 1890	0·363 4545	0·390 1351	2·563 215	0·931 6120	45
16	·359 4540	·385 1996	·596 056	·933 1628	·363 5222	·390 2189	·562 665	·931 5855	44
17	·359 5218	·385 2832	·595 494	·933 1367	·363 5900	·390 3026	·562 114	·931 5591	43
18	·359 5897	·385 3667	·594 931	·933 1105	·363 6577	·390 3865	·561 564	·931 5326	42
19	·359 6576	·385 4502	·594 369	·933 0844	·363 7255	·390 4703	·561 015	·931 5062	41
20	0·359 7254	0·385 5337	2·593 807	0·933 0582	0·363 7932	0·390 5541	2·560 465	0·931 4797	40
21	·359 7933	·385 6173	·593 245	·933 0321	·363 8609	·390 6379	·559 916	·931 4533	39
22	·359 8611	·385 7008	·592 683	·933 0059	·363 9287	·390 7217	·559 366	·931 4268	38
23	·359 9290	·385 7843	·592 122	·932 9797	·363 9964	·390 8055	·558 817	·931 4003	37
24	·359 9968	·385 8679	·591 561	·932 9535	·364 0641	·390 8894	·558 269	·931 3739	36
25	0·360 0647	0·385 9514	2·591 000	0·932 9274	0·364 1319	0·390 9732	2·557 720	0·931 3474	35
26	·360 1325	·386 0350	·590 439	·932 9012	·364 1996	·391 0570	·557 172	·931 3209	34
27	·360 2003	·386 1186	·589 878	·932 8750	·364 2673	·391 1409	·556 624	·931 2944	33
28	·360 2682	·386 2021	·589 318	·932 8488	·364 3351	·391 2247	·556 076	·931 2679	32
29	·360 3360	·386 2857	·588 758	·932 8226	·364 4028	·391 3086	·555 528	·931 2414	31
30	0·360 4039	0·386 3693	2·588 198	0·932 7964	0·364 4705	0·391 3925	2·554 980	0·931 2149	30
31	·360 4717	·386 4529	·587 638	·932 7702	·364 5382	·391 4763	·554 433	·931 1884	29
32	·360 5395	·386 5364	·587 078	·932 7439	·364 6059	·391 5602	·553 886	·931 1619	28
33	·360 6073	·386 6200	·586 519	·932 7177	·364 6737	·391 6441	·553 339	·931 1354	27
34	·360 6752	·386 7036	·585 960	·932 6915	·364 7414	·391 7279	·552 792	·931 1089	26
35	0·360 7430	0·386 7872	2·585 401	0·932 6653	0·364 8091	0·391 8118	2·552 246	0·931 0823	25
36	·360 8108	·386 8708	·584 842	·932 6390	·364 8768	·391 8957	·551 699	·931 0558	24
37	·360 8786	·386 9544	·584 284	·932 6128	·364 9445	·391 9796	·551 153	·931 0293	23
38	·360 9465	·387 0380	·583 725	·932 5865	·365 0122	·392 0635	·550 607	·931 0027	22
39	·361 0143	·387 1217	·583 167	·932 5603	·365 0799	·392 1474	·550 061	·930 9762	21
40	0·361 0821	0·387 2053	2·582 609	0·932 5340	0·365 1476	0·392 2313	2·549 516	0·930 9496	20
41	·361 1499	·387 2889	·582 052	·932 5078	·365 2153	·392 3152	·548 971	·930 9231	19
42	·361 2177	·387 3725	·581 494	·932 4815	·365 2830	·392 3991	·548 426	·930 8965	18
43	·361 2855	·387 4562	·580 937	·932 4552	·365 3507	·392 4831	·547 881	·930 8700	17
44	·361 3534	·387 5398	·580 380	·932 4290	·365 4184	·392 5670	·547 336	·930 8434	16
45	0·361 4212	0·387 6235	2·579 823	0·932 4027	0·365 4861	0·392 6509	2·546 791	0·930 8168	15
46	·361 4890	·387 7071	·579 267	·932 3764	·365 5538	·392 7349	·546 247	·930 7902	14
47	·361 5568	·387 7908	·578 710	·932 3501	·365 6215	·392 8188	·545 703	·930 7636	13
48	·361 6246	·387 8744	·578 154	·932 3238	·365 6891	·392 9027	·545 159	·930 7370	12
49	·361 6924	·387 9581	·577 598	·932 2975	·365 7568	·392 9867	·544 615	·930 7105	11
50	0·361 7602	0·388 0418	2·577 042	0·932 2712	0·365 8245	0·393 0707	2·544 072	0·930 6838	10
51	·361 8280	·388 1254	·576 487	·932 2449	·365 8922	·393 1546	·543 529	·930 6572	09
52	·361 8958	·388 2091	·575 931	·932 2186	·365 9599	·393 2386	·542 985	·930 6306	08
53	·361 9635	·388 2928	·575 376	·932 1922	·366 0275	·393 3226	·542 443	·930 6040	07
54	·362 0313	·388 3765	·574 821	·932 1659	·366 0952	·393 4065	·541 900	·930 5774	06
55	0·362 0991	0·388 4602	2·574 266	0·932 1396	0·366 1629	0·393 4905	2·541 357	0·930 5508	05
56	·362 1669	·388 5439	·573 712	·932 1133	·366 2306	·393 5745	·540 815	·930 5241	04
57	·362 2347	·388 6276	·573 157	·932 0869	·366 2982	·393 6585	·540 273	·930 4975	03
58	·362 3025	·388 7113	·572 603	·932 0606	·366 3659	·393 7425	·539 731	·930 4709	02
59	·362 3703	·388 7950	·572 049	·932 0342	·366 4336	·393 8265	·539 189	·930 4442	01
60	0·362 4380	0·388 8787	2·571 496	0·932 0079	0·366 5012	0·393 9105	2·538 648	0·930 4176	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	677–679	837–834	553–566	264–260	676–678	840–837	541–554	267–263	d

$4^{h}\ 35^{m}$ $4^{h}\ 34^{m}$

	1^{h} 26^{m}				1^{h} 27^{m}				
d	677–675	840–843	541–529	266–270	676–674	843–846	530–518	269–273	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·366 5012	0·393 9105	2·538 648	0·930 4176	0·370 5574	0·398 9595	2·506 520	0·928 8096	60
01	·366 5689	·393 9945	·538 107	·930 3909	·370 6250	·399 0438	·505 990	·928 7826	59
02	·366 6365	·394 0785	·537 566	·930 3643	·370 6925	·399 1282	·505 461	·928 7556	58
03	·366 7042	·394 1625	·537 025	·930 3376	·370 7601	·399 2125	·504 932	·928 7287	57
04	·366 7719	·394 2465	·536 484	·930 3109	·370 8276	·399 2968	·504 403	·928 7017	56
05	0·366 8395	0·394 3306	2·535 943	0·930 2842	0·370 8951	0·399 3811	2·503 874	0·928 6748	55
06	·366 9072	·394 4146	·535 403	·930 2576	·370 9627	·399 4654	·503 346	·928 6478	54
07	·366 9748	·394 4986	·534 863	·930 2309	·371 0302	·399 5497	·502 817	·928 6208	53
08	·367 0425	·394 5827	·534 323	·930 2042	·371 0977	·399 6341	·502 289	·928 5938	52
09	·367 1101	·394 6667	·533 783	·930 1775	·371 1653	·399 7184	·501 761	·928 5668	51
10	0·367 1777	0·394 7508	2·533 244	0·930 1508	0·371 2328	0·399 8028	2·501 233	0·928 5398	50
11	·367 2454	·394 8348	·532 705	·930 1241	·371 3003	·399 8871	·500 706	·928 5128	49
12	·367 3130	·394 9189	·532 165	·930 0974	·371 3678	·399 9715	·500 178	·928 4858	48
13	·367 3807	·395 0030	·531 627	·930 0707	·371 4354	·400 0558	·499 651	·928 4588	47
14	·367 4483	·395 0870	·531 088	·930 0439	·371 5029	·400 1402	·499 124	·928 4318	46
15	0·367 5159	0·395 1711	2·530 549	0·930 0172	0·371 5704	0·400 2246	2·498 597	0·928 4048	45
16	·367 5836	·395 2552	·530 011	·929 9905	·371 6379	·400 3089	·498 071	·928 3778	44
17	·367 6512	·395 3393	·529 473	·929 9638	·371 7054	·400 3933	·497 544	·928 3507	43
18	·367 7188	·395 4234	·528 935	·929 9370	·371 7729	·400 4777	·497 018	·928 3237	42
19	·367 7865	·395 5075	·528 397	·929 9103	·371 8404	·400 5621	·496 492	·928 2967	41
20	0·367 8541	0·395 5916	2·527 860	0·929 8835	0·371 9079	0·400 6465	2·495 966	0·928 2696	40
21	·367 9217	·395 6757	·527 322	·929 8568	·371 9754	·400 7309	·495 440	·928 2426	39
22	·367 9893	·395 7598	·526 785	·929 8300	·372 0430	·400 8153	·494 915	·928 2155	38
23	·368 0569	·395 8439	·526 248	·929 8033	·372 1105	·400 8997	·494 390	·928 1885	37
24	·368 1246	·395 9280	·525 712	·929 7765	·372 1780	·400 9841	·493 865	·928 1614	36
25	0·368 1922	0·396 0121	2·525 175	0·929 7497	0·372 2454	0·401 0685	2·493 340	0·928 1343	35
26	·368 2598	·396 0963	·524 639	·929 7229	·372 3129	·401 1529	·492 815	·928 1073	34
27	·368 3274	·396 1804	·524 103	·929 6962	·372 3804	·401 2374	·492 290	·928 0802	33
28	·368 3950	·396 2645	·523 567	·929 6694	·372 4479	·401 3218	·491 766	·928 0531	32
29	·368 4626	·396 3487	·523 031	·929 6426	·372 5154	·401 4062	·491 242	·928 0260	31
30	0·368 5302	0·396 4328	2·522 495	0·929 6158	0·372 5829	0·401 4907	2·490 718	0·927 9989	30
31	·368 5978	·396 5170	·521 960	·929 5890	·372 6504	·401 5751	·490 194	·927 9718	29
32	·368 6654	·396 6011	·521 425	·929 5622	·372 7179	·401 6596	·489 671	·927 9447	28
33	·368 7330	·396 6853	·520 890	·929 5353	·372 7854	·401 7440	·489 147	·927 9176	27
34	·368 8006	·396 7695	·520 355	·929 5085	·372 8528	·401 8285	·488 624	·927 8905	26
35	0·368 8682	0·396 8536	2·519 821	0·929 4817	0·372 9203	0·401 9130	2·488 101	0·927 8634	25
36	·368 9358	·396 9378	·519 286	·929 4549	·372 9878	·401 9974	·487 578	·927 8363	24
37	·369 0034	·397 0220	·518 752	·929 4281	·373 0553	·402 0819	·487 056	·927 8091	23
38	·369 0710	·397 1062	·518 218	·929 4012	·373 1227	·402 1664	·486 533	·927 7820	22
39	·369 1386	·397 1904	·517 684	·929 3744	·373 1902	·402 2509	·486 011	·927 7549	21
40	0·369 2061	0·397 2746	2·517 151	0·929 3475	0·373 2577	0·402 3354	2·485 489	0·927 7277	20
41	·369 2737	·397 3588	·516 617	·929 3207	·373 3251	·402 4199	·484 967	·927 7006	19
42	·369 3413	·397 4430	·516 084	·929 2938	·373 3926	·402 5044	·484 445	·927 6734	18
43	·369 4089	·397 5272	·515 551	·929 2670	·373 4601	·402 5889	·483 924	·927 6463	17
44	·369 4765	·397 6114	·515 018	·929 2401	·373 5275	·402 6734	·483 402	·927 6191	16
45	0·369 5440	0·397 6956	2·514 486	0·929 2132	0·373 5950	0·402 7579	2·482 881	0·927 5919	15
46	·369 6116	·397 7799	·513 953	·929 1863	·373 6624	·402 8424	·482 360	·927 5648	14
47	·369 6792	·397 8641	·513 421	·929 1595	·373 7299	·402 9269	·481 840	·927 5376	13
48	·369 7468	·397 9483	·512 889	·929 1326	·373 7973	·403 0115	·481 319	·927 5104	12
49	·369 8143	·398 0326	·512 357	·929 1057	·373 8648	·403 0960	·480 799	·927 4832	11
50	0·369 8819	0·398 1168	2·511 826	0·929 0788	0·373 9322	0·403 1805	2·480 278	0·927 4560	10
51	·369 9495	·398 2011	·511 294	·929 0519	·373 9997	·403 2651	·479 758	·927 4288	09
52	·370 0170	·398 2853	·510 763	·929 0250	·374 0671	·403 3496	·479 239	·927 4016	08
53	·370 0846	·398 3696	·510 232	·928 9981	·374 1346	·403 4342	·478 719	·927 3744	07
54	·370 1521	·398 4539	·509 701	·928 9712	·374 2020	·403 5188	·478 200	·927 3472	06
55	0·370 2197	0·398 5381	2·509 170	0·928 9442	0·374 2694	0·403 6033	2·477 680	0·927 3200	05
56	·370 2872	·398 6224	·508 640	·928 9173	·374 3369	·403 6879	·477 161	·927 2928	04
57	·370 3548	·398 7067	·508 109	·928 8904	·374 4043	·403 7725	·476 642	·927 2656	03
58	·370 4223	·398 7910	·507 579	·928 8634	·374 4717	·403 8570	·476 124	·927 2383	02
59	·370 4899	·398 8753	·507 050	·928 8365	·374 5392	·403 9416	·475 605	·927 2111	01
60	0·370 5574	0·398 9595	2·506 520	0·928 8096	0·374 6066	0·404 0262	2·475 087	0·927 1839	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	675–677	843–840	529–541	270–266	674–676	846–843	518–530	273–269	d
	4^{h} 33^{m}				4^{h} 32^{m}				

$1^h\ 28^m$ $1^h\ 29^m$

d	675–673	846–849	518–507	272–276	673–671	849–852	508–496	275–279	d
	sin	tan	cot	cos	sin	tan	cot	cos	
s									
00	0·374 6066	0·404 0262	2·475 087	0·927 1839	0·378 6486	0·409 1108	2·444 326	0·925 5405	60
01	·374 6740	·404 1108	·474 569	·927 1566	·378 7159	·409 1957	·443 818	·925 5130	59
02	·374 7414	·404 1954	·474 051	·927 1294	·378 7832	·409 2806	·443 312	·925 4854	58
03	·374 8089	·404 2800	·473 533	·927 1021	·378 8505	·409 3655	·442 805	·925 4579	57
04	·374 8763	·404 3646	·473 015	·927 0748	·378 9178	·409 4504	·442 298	·925 4303	56
05	0·374 9437	0·404 4493	2·472 498	0·927 0476	0·378 9851	0·409 5353	2·441 792	0·925 4028	55
06	·375 0111	·404 5339	·471 981	·927 0203	·379 0524	·409 6203	·441 286	·925 3752	54
07	·375 0785	·404 6185	·471 464	·926 9930	·379 1197	·409 7052	·440 779	·925 3476	53
08	·375 1459	·404 7031	·470 947	·926 9658	·379 1870	·409 7901	·440 274	·925 3201	52
09	·375 2134	·404 7878	·470 430	·926 9385	·379 2543	·409 8750	·439 768	·925 2925	51
10	0·375 2808	0·404 8724	2·469 914	0·926 9112	0·379 3216	0·409 9600	2·439 262	0·925 2649	50
11	·375 3482	·404 9570	·469 398	·926 8839	·379 3889	·410 0449	·438 757	·925 2373	49
12	·375 4156	·405 0417	·468 882	·926 8566	·379 4562	·410 1299	·438 252	·925 2097	48
13	·375 4830	·405 1264	·468 366	·926 8293	·379 5234	·410 2148	·437 747	·925 1821	47
14	·375 5504	·405 2110	·467 850	·926 8020	·379 5907	·410 2998	·437 242	·925 1545	46
15	0·375 6178	0·405 2957	2·467 334	0·926 7747	0·379 6580	0·410 3848	2·436 738	0·925 1269	45
16	·375 6852	·405 3804	·466 819	·926 7474	·379 7253	·410 4697	·436 233	·925 0993	44
17	·375 7526	·405 4650	·466 304	·926 7200	·379 7926	·410 5547	·435 729	·925 0717	43
18	·375 8200	·405 5497	·465 789	·926 6927	·379 8598	·410 6397	·435 225	·925 0441	42
19	·375 8873	·405 6344	·465 274	·926 6654	·379 9271	·410 7247	·434 721	·925 0164	41
20	0·375 9547	0·405 7191	2·464 760	0·926 6380	0·379 9944	0·410 8097	2·434 217	0·924 9888	40
21	·376 0221	·405 8038	·464 245	·926 6107	·380 0616	·410 8947	·433 714	·924 9612	39
22	·376 0895	·405 8885	·463 731	·926 5833	·380 1289	·410 9797	·433 210	·924 9335	38
23	·376 1569	·405 9732	·463 217	·926 5560	·380 1962	·411 0647	·432 707	·924 9059	37
24	·376 2243	·406 0579	·462 703	·926 5286	·380 2634	·411 1497	·432 204	·924 8782	36
25	0·376 2916	0·406 1426	2·462 189	0·926 5013	0·380 3307	0·411 2347	2·431 701	0·924 8506	35
26	·376 3590	·406 2273	·461 676	·926 4739	·380 3979	·411 3197	·431 199	·924 8229	34
27	·376 4264	·406 3121	·461 163	·926 4465	·380 4652	·411 4048	·430 696	·924 7952	33
28	·376 4938	·406 3968	·460 649	·926 4192	·380 5324	·411 4898	·430 194	·924 7676	32
29	·376 5611	·406 4815	·460 136	·926 3918	·380 5997	·411 5748	·429 692	·924 7399	31
30	0·376 6285	0·406 5663	2·459 624	0·926 3644	0·380 6669	0·411 6599	2·429 190	0·924 7122	30
31	·376 6959	·406 6510	·459 111	·926 3370	·380 7342	·411 7449	·428 688	·924 6845	29
32	·376 7632	·406 7358	·458 599	·926 3096	·380 8014	·411 8300	·428 186	·924 6568	28
33	·376 8306	·406 8205	·458 086	·926 2822	·380 8687	·411 9151	·427 685	·924 6291	27
34	·376 8980	·406 9053	·457 574	·926 2548	·380 9359	·412 0001	·427 184	·924 6014	26
35	0·376 9653	0·406 9900	2·457 063	0·926 2274	0·381 0031	0·412 0852	2·426 683	0·924 5737	25
36	·377 0327	·407 0748	·456 551	·926 2000	·381 0704	·412 1703	·426 182	·924 5460	24
37	·377 1000	·407 1596	·456 039	·926 1725	·381 1376	·412 2553	·425 681	·924 5183	23
38	·377 1674	·407 2444	·455 528	·926 1451	·381 2048	·412 3404	·425 181	·924 4906	22
39	·377 2347	·407 3291	·455 017	·926 1177	·381 2721	·412 4255	·424 680	·924 4629	21
40	0·377 3021	0·407 4139	2·454 506	0·926 0902	0·381 3393	0·412 5106	2·424 180	0·924 4351	20
41	·377 3694	·407 4987	·453 995	·926 0628	·381 4065	·412 5957	·423 680	·924 4074	19
42	·377 4368	·407 5835	·453 485	·926 0354	·381 4737	·412 6808	·423 180	·924 3797	18
43	·377 5041	·407 6683	·452 974	·926 0079	·381 5410	·412 7659	·422 681	·924 3519	17
44	·377 5714	·407 7531	·452 464	·925 9805	·381 6082	·412 8510	·422 181	·924 3242	16
45	0·377 6388	0·407 8380	2·451 954	0·925 9530	0·381 6754	0·412 9362	2·421 682	0·924 2964	15
46	·377 7061	·407 9228	·451 444	·925 9255	·381 7426	·413 0213	·421 183	·924 2687	14
47	·377 7735	·408 0076	·450 935	·925 8981	·381 8098	·413 1064	·420 684	·924 2409	13
48	·377 8408	·408 0924	·450 425	·925 8706	·381 8770	·413 1915	·420 185	·924 2131	12
49	·377 9081	·408 1773	·449 916	·925 8431	·381 9443	·413 2767	·419 686	·924 1854	11
50	0·377 9754	0·408 2621	2·449 407	0·925 8156	0·382 0115	0·413 3618	2·419 188	0·924 1576	10
51	·378 0428	·408 3470	·448 898	·925 7881	·382 0787	·413 4470	·418 690	·924 1298	09
52	·378 1101	·408 4318	·448 389	·925 7606	·382 1459	·413 5321	·418 192	·924 1020	08
53	·378 1774	·408 5167	·447 881	·925 7331	·382 2131	·413 6173	·417 694	·924 0742	07
54	·378 2447	·408 6015	·447 372	·925 7056	·382 2803	·413 7025	·417 196	·924 0464	06
55	0·378 3121	0·408 6864	2·446 864	0·925 6781	0·382 3475	0·413 7876	2·416 699	0·924 0186	05
56	·378 3794	·408 7713	·446 356	·925 6506	·382 4147	·413 8728	·416 201	·923 9908	04
57	·378 4467	·408 8561	·445 848	·925 6231	·382 4819	·413 9580	·415 704	·923 9630	03
58	·378 5140	·408 9410	·445 340	·925 5956	·382 5491	·414 0432	·415 207	·923 9352	02
59	·378 5813	·409 0259	·444 833	·925 5680	·382 6162	·414 1284	·414 710	·923 9074	01
60	0·378 6486	0·409 1108	2·444 326	0·925 5405	0·382 6834	0·414 2136	2·414 214	0·923 8795	00
									s
	cos	cot	tan	sin	cos	cot	tan	sin	
d	673–675	849–846	507–518	276–272	671–673	852–849	496–508	279–275	d

$4^h\ 31^m$ $4^h\ 30^m$

$1^{h}\ 30^{m}$ $1^{h}\ 31^{m}$

d	672–670	852–855	497–486	278–281	671–669	855–858	486–476	281–284	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·382 6834	0·414 2136	2·414 214	0·923 8795	0·386 7110	0·419 3348	2·384 729	0·922 2010	60
01	·382 7506	·414 2988	·413 717	·923 8517	·386 7780	·419 4203	·384 243	·922 1728	59
02	·382 8178	·414 3840	·413 221	·923 8239	·386 8451	·419 5058	·383 757	·922 1447	58
03	·382 8850	·414 4692	·412 725	·923 7960	·386 9121	·419 5914	·383 271	·922 1166	57
04	·382 9522	·414 5544	·412 229	·923 7682	·386 9792	·419 6769	·382 786	·922 0884	56
05	0·383 0193	0·414 6396	2·411 733	0·923 7403	0·387 0463	0·419 7624	2·382 300	0·922 0603	55
06	·383 0865	·414 7248	·411 237	·923 7125	·387 1133	·419 8480	·381 815	·922 0321	54
07	·383 1537	·414 8101	·410 742	·923 6846	·387 1804	·419 9335	·381 329	·922 0040	53
08	·383 2209	·414 8953	·410 247	·923 6567	·387 2474	·420 0190	·380 844	·921 9758	52
09	·383 2880	·414 9806	·409 751	·923 6289	·387 3145	·420 1046	·380 360	·921 9477	51
10	0·383 3552	0·415 0658	2·409 256	0·923 6010	0·387 3815	0·420 1902	2·379 875	0·921 9195	50
11	·383 4224	·415 1511	·408 762	·923 5731	·387 4485	·420 2757	·379 390	·921 8913	49
12	·383 4895	·415 2363	·408 267	·923 5452	·387 5156	·420 3613	·378 906	·921 8632	48
13	·383 5567	·415 3216	·407 773	·923 5173	·387 5826	·420 4469	·378 422	·921 8350	47
14	·383 6238	·415 4069	·407 279	·923 4894	·387 6497	·420 5324	·377 938	·921 8068	46
15	0·383 6910	0·415 4921	2·406 784	0·923 4615	0·387 7167	0·420 6180	2·377 454	0·921 7786	45
16	·383 7582	·415 5774	·406 291	·923 4336	·387 7837	·420 7036	·376 970	·921 7504	44
17	·383 8253	·415 6627	·405 797	·923 4057	·387 8508	·420 7892	·376 487	·921 7222	43
18	·383 8925	·415 7480	·405 303	·923 3778	·387 9178	·420 8748	·376 003	·921 6940	42
19	·383 9596	·415 8333	·404 810	·923 3499	·387 9848	·420 9604	·375 520	·921 6658	41
20	0·384 0268	0·415 9186	2·404 317	0·923 3220	0·388 0518	0·421 0460	2·375 037	0·921 6375	40
21	·384 0939	·416 0039	·403 824	·923 2940	·388 1189	·421 1317	·374 554	·921 6093	39
22	·384 1610	·416 0892	·403 331	·923 2661	·388 1859	·421 2173	·374 072	·921 5811	38
23	·384 2282	·416 1745	·402 838	·923 2382	·388 2529	·421 3029	·373 589	·921 5529	37
24	·384 2953	·416 2598	·402 346	·923 2102	·388 3199	·421 3885	·373 107	·921 5246	36
25	0·384 3625	0·416 3451	2·401 853	0·923 1823	0·388 3869	0·421 4742	2·372 625	0·921 4964	35
26	·384 4296	·416 4305	·401 361	·923 1543	·388 4539	·421 5598	·372 143	·921 4681	34
27	·384 4967	·416 5158	·400 869	·923 1264	·388 5210	·421 6455	·371 661	·921 4399	33
28	·384 5639	·416 6012	·400 377	·923 0984	·388 5880	·421 7311	·371 179	·921 4116	32
29	·384 6310	·416 6865	·399 886	·923 0704	·388 6550	·421 8168	·370 698	·921 3834	31
30	0·384 6981	0·416 7719	2·399 394	0·923 0424	0·388 7220	0·421 9024	2·370 216	0·921 3551	30
31	·384 7652	·416 8572	·398 903	·923 0145	·388 7890	·421 9881	·369 735	·921 3268	29
32	·384 8324	·416 9426	·398 412	·922 9865	·388 8560	·422 0738	·369 254	·921 2986	28
33	·384 8995	·417 0279	·397 921	·922 9585	·388 9230	·422 1595	·368 773	·921 2703	27
34	·384 9666	·417 1133	·397 430	·922 9305	·388 9900	·422 2452	·368 292	·921 2420	26
35	0·385 0337	0·417 1987	2·396 939	0·922 9025	0·389 0570	0·422 3308	2·367 812	0·921 2137	25
36	·385 1008	·417 2841	·396 449	·922 8745	·389 1240	·422 4165	·367 332	·921 1854	24
37	·385 1679	·417 3695	·395 959	·922 8465	·389 1909	·422 5022	·366 851	·921 1571	23
38	·385 2351	·417 4548	·395 469	·922 8185	·389 2579	·422 5879	·366 371	·921 1288	22
39	·385 3022	·417 5402	·394 979	·922 7905	·389 3249	·422 6737	·365 891	·921 1005	21
40	0·385 3693	0·417 6257	2·394 489	0·922 7624	0·389 3919	0·422 7594	2·365 412	0·921 0722	20
41	·385 4364	·417 7111	·393 999	·922 7344	·389 4589	·422 8451	·364 932	·921 0439	19
42	·385 5035	·417 7965	·393 510	·922 7064	·389 5259	·422 9308	·364 453	·921 0155	18
43	·385 5706	·417 8819	·393 021	·922 6783	·389 5928	·423 0166	·363 974	·920 9872	17
44	·385 6377	·417 9673	·392 532	·922 6503	·389 6598	·423 1023	·363 495	·920 9589	16
45	0·385 7048	0·418 0527	2·392 043	0·922 6223	0·389 7268	0·423 1880	2·363 016	0·920 9305	15
46	·385 7719	·418 1382	·391 554	·922 5942	·389 7938	·423 2738	·362 537	·920 9022	14
47	·385 8390	·418 2236	·391 065	·922 5662	·389 8607	·423 3595	·362 059	·920 8738	13
48	·385 9060	·418 3091	·390 577	·922 5381	·389 9277	·423 4453	·361 580	·920 8455	12
49	·385 9731	·418 3945	·390 089	·922 5100	·389 9947	·423 5311	·361 102	·920 8171	11
50	0·386 0402	0·418 4800	2·389 601	0·922 4820	0·390 0616	0·423 6168	2·360 624	0·920 7888	10
51	·386 1073	·418 5654	·389 113	·922 4539	·390 1286	·423 7026	·360 146	·920 7604	09
52	·386 1744	·418 6509	·388 625	·922 4258	·390 1955	·423 7884	·359 668	·920 7320	08
53	·386 2415	·418 7364	·388 137	·922 3977	·390 2625	·423 8742	·359 191	·920 7036	07
54	·386 3085	·418 8218	·387 650	·922 3696	·390 3294	·423 9600	·358 713	·920 6753	06
55	0·386 3756	0·418 9073	2·387 163	0·922 3415	0·390 3964	0·424 0458	2·358 236	0·920 6469	05
56	·386 4427	·418 9928	·386 676	·922 3134	·390 4633	·424 1316	·357 759	·920 6185	04
57	·386 5098	·419 0783	·386 189	·922 2853	·390 5303	·424 2174	·357 282	·920 5901	03
58	·386 5768	·419 1638	·385 702	·922 2572	·390 5972	·424 3032	·356 805	·920 5617	02
59	·386 6439	·419 2493	·385 216	·922 2291	·390 6642	·424 3890	·356 329	·920 5333	01
60	0·386 7110	0·419 3348	2·384 729	0·922 2010	0·390 7311	0·424 4748	2·355 852	0·920 5049	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	670–672	855–852	486–497	281–278	669–671	858–855	476–486	284–281	d

$4^{h}\ 29^{m}$ $4^{h}\ 28^{m}$

$1^h\ 32^m$ $1^h\ 33^m$

d	670–668	858–862	476–467	284–287	668–667	861–865	467–457	287–290	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·390 7311	0·424 4748	2·355 852	0·920 5049	0·394 7439	0·429 6339	2·327 563	0·918 7912	60
01	·390 7981	·424 5606	·355 376	·920 4764	·394 8107	·429 7201	·327 096	·918 7625	59
02	·390 8650	·424 6465	·354 900	·920 4480	·394 8775	·429 8062	·326 630	·918 7338	58
03	·390 9319	·424 7323	·354 424	·920 4196	·394 9443	·429 8924	·326 164	·918 7051	57
04	·390 9989	·424 8182	·353 948	·920 3912	·395 0111	·429 9785	·325 698	·918 6763	56
05	0·391 0658	0·424 9040	2·353 473	0·920 3627	0·395 0779	0·430 0647	2·325 232	0·918 6476	55
06	·391 1327	·424 9899	·352 997	·920 3343	·395 1447	·430 1509	·324 766	·918 6189	54
07	·391 1997	·425 0757	·352 522	·920 3058	·395 2115	·430 2371	·324 300	·918 5901	53
08	·391 2666	·425 1616	·352 047	·920 2774	·395 2783	·430 3232	·323 835	·918 5614	52
09	·391 3335	·425 2475	·351 572	·920 2489	·395 3451	·430 4094	·323 369	·918 5327	51
10	0·391 4004	0·425 3333	2·351 097	0·920 2205	0·395 4119	0·430 4956	2·322 904	0·918 5039	50
11	·391 4674	·425 4192	·350 623	·920 1920	·395 4787	·430 5818	·322 439	·918 4751	49
12	·391 5343	·425 5051	·350 148	·920 1635	·395 5455	·430 6680	·321 974	·918 4464	48
13	·391 6012	·425 5910	·349 674	·920 1351	·395 6123	·430 7543	·321 509	·918 4176	47
14	·391 6681	·425 6769	·349 200	·920 1066	·395 6791	·430 8405	·321 045	·918 3888	46
15	0·391 7350	0·425 7628	2·348 726	0·920 0781	0·395 7459	0·430 9267	2·320 580	0·918 3601	45
16	·391 8019	·425 8487	·348 252	·920 0496	·395 8127	·431 0129	·320 116	·918 3313	44
17	·391 8688	·425 9346	·347 778	·920 0211	·395 8794	·431 0992	·319 652	·918 3025	43
18	·391 9357	·426 0205	·347 305	·919 9926	·395 9462	·431 1854	·319 188	·918 2737	42
19	·392 0026	·426 1064	·346 831	·919 9641	·396 0130	·431 2716	·318 724	·918 2449	41
20	0·392 0695	0·426 1924	2·346 358	0·919 9356	0·396 0798	0·431 3579	2·318 261	0·918 2161	40
21	·392 1364	·426 2783	·345 885	·919 9071	·396 1465	·431 4442	·317 797	·918 1873	39
22	·392 2033	·426 3643	·345 412	·919 8786	·396 2133	·431 5304	·317 334	·918 1585	38
23	·392 2702	·426 4502	·344 940	·919 8500	·396 2801	·431 6167	·316 871	·918 1297	37
24	·392 3371	·426 5361	·344 467	·919 8215	·396 3468	·431 7030	·316 408	·918 1009	36
25	0·392 4040	0·426 6221	2·343 995	0·919 7930	0·396 4136	0·431 7892	2·315 945	0·918 0720	35
26	·392 4709	·426 7081	·343 523	·919 7644	·396 4804	·431 8755	·315 482	·918 0432	34
27	·392 5378	·426 7940	·343 051	·919 7359	·396 5471	·431 9618	·315 020	·918 0144	33
28	·392 6047	·426 8800	·342 579	·919 7073	·396 6139	·432 0481	·314 557	·917 9855	32
29	·392 6715	·426 9660	·342 107	·919 6788	·396 6807	·432 1344	·314 095	·917 9567	31
30	0·392 7384	0·427 0520	2·341 635	0·919 6502	0·396 7474	0·432 2207	2·313 633	0·917 9278	30
31	·392 8053	·427 1379	·341 164	·919 6217	·396 8142	·432 3070	·313 171	·917 8990	29
32	·392 8722	·427 2239	·340 693	·919 5931	·396 8809	·432 3933	·312 709	·917 8701	28
33	·392 9391	·427 3099	·340 222	·919 5645	·396 9477	·432 4796	·312 248	·917 8412	27
34	·393 0059	·427 3959	·339 751	·919 5359	·397 0144	·432 5660	·311 786	·917 8124	26
35	0·393 0728	0·427 4819	2·339 280	0·919 5074	0·397 0811	0·432 6523	2·311 325	0·917 7835	25
36	·393 1397	·427 5680	·338 809	·919 4788	·397 1479	·432 7386	·310 864	·917 7546	24
37	·393 2065	·427 6540	·338 339	·919 4502	·397 2146	·432 8250	·310 403	·917 7257	23
38	·393 2734	·427 7400	·337 869	·919 4216	·397 2814	·432 9113	·309 942	·917 6969	22
39	·393 3403	·427 8260	·337 399	·919 3930	·397 3481	·432 9977	·309 481	·917 6680	21
40	0·393 4071	0·427 9121	2·336 929	0·919 3644	0·397 4148	0·433 0840	2·309 021	0·917 6391	20
41	·393 4740	·427 9981	·336 459	·919 3358	·397 4816	·433 1704	·308 560	·917 6102	19
42	·393 5408	·428 0842	·335 989	·919 3071	·397 5483	·433 2568	·308 100	·917 5812	18
43	·393 6077	·428 1702	·335 520	·919 2785	·397 6150	·433 3432	·397 640	·917 5523	17
44	·393 6745	·428 2563	·335 050	·919 2499	·397 6818	·433 4295	·307 180	·917 5234	16
45	0·393 7414	0·428 3423	2·334 581	0·919 2213	0·397 7485	0·433 5159	2·306 720	0·917 4945	15
46	·393 8082	·428 4284	·334 112	·919 1926	·397 8152	·433 6023	·306 261	·917 4656	14
47	·393 8751	·428 5145	·333 643	·919 1640	·397 8819	·433 6887	·305 801	·917 4366	13
48	·393 9419	·428 6005	·333 175	·919 1353	·397 9486	·433 7751	·305 342	·917 4077	12
49	·394 0087	·428 6866	·332 706	·919 1067	·398 0153	·433 8615	·304 883	·917 3788	11
50	0·394 0756	0·428 7727	2·332 238	0·919 0780	0·398 0821	0·433 9479	2·304 424	0·917 3498	10
51	·394 1424	·428 8588	·331 770	·919 0494	·398 1488	·434 0344	·303 965	·917 3209	09
52	·394 2093	·428 9449	·331 302	·919 0207	·398 2155	·434 1208	·303 506	·917 2919	08
53	·394 2761	·429 0310	·330 834	·918 9920	·398 2822	·434 2072	·303 048	·917 2629	07
54	·394 3429	·429 1171	·330 366	·918 9634	·398 3489	·434 2936	·302 590	·917 2340	06
55	0·394 4097	0·429 2032	2·329 899	0·918 9347	0·398 4156	0·434 3801	2·302 131	0·917 2050	05
56	·394 4766	·429 2894	·329 431	·918 9060	·398 4823	·434 4665	·301 673	·917 1760	04
57	·394 5434	·429 3755	·328 964	·918 8773	·398 5490	·434 5530	·301 215	·917 1470	03
58	·394 6102	·429 4616	·328 497	·918 8486	·398 6157	·434 6394	·300 758	·917 1181	02
59	·394 6770	·429 5478	·328 030	·918 8199	·398 6824	·434 7259	·300 300	·917 0891	01
60	0·394 7439	0·429 6339	2·327 563	0·918 7912	0·398 7491	0·434 8124	2·299 843	0·917 0601	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	668–670	862–858	467–476	287–284	667–668	865–861	457–467	290–287	d

$4^h\ 27^m$ $4^h\ 26^m$

d	667–665	864–868	458–448	290–293	666–664	868–872	448–439	293–296	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·398 7491	0·434 8124	2·299 843	0·917 0601	0·402 7467	0·440 0105	2·272 673	0·915 3115	60
01	·398 8158	·434 8988	·299 385	·917 0311	·402 8133	·440 0973	·272 225	·915 2822	59
02	·398 8824	·434 9853	·298 928	·917 0021	·402 8798	·440 1841	·271 777	·915 2529	58
03	·398 9491	·435 0718	·298 471	·916 9731	·402 9464	·440 2710	·271 329	·915 2236	57
04	·399 0158	·435 1583	·298 014	·916 9440	·403 0129	·440 3578	·270 881	·915 1943	56
05	0·399 0825	0·435 2448	2·297 558	0·916 9150	0·403 0795	0·440 4446	2·270 433	0·915 1650	55
06	·399 1492	·435 3313	·297 101	·916 8860	·403 1460	·440 5314	·269 986	·915 1357	54
07	·399 2159	·435 4178	·296 645	·916 8570	·403 2126	·440 6183	·269 538	·915 1063	53
08	·399 2825	·435 5043	·296 188	·916 8279	·403 2791	·440 7051	·269 091	·915 0770	52
09	·399 3492	·435 5908	·295 732	·916 7989	·403 3457	·440 7920	·268 644	·915 0477	51
10	0·399 4159	0·435 6774	2·295 276	0·916 7699	0·403 4122	0·440 8788	2·268 197	0·915 0184	50
11	·399 4825	·435 7639	·294 821	·916 7408	·403 4788	·440 9657	·267 750	·914 9890	49
12	·399 5492	·435 8504	·294 365	·916 7118	·403 5453	·441 0526	·267 304	·914 9597	48
13	·399 6159	·435 9370	·293 910	·916 6827	·403 6118	·441 1394	·266 857	·914 9303	47
14	·399 6825	·436 0235	·293 454	·916 6536	·403 6784	·441 2263	·266 411	·914 9010	46
15	0·399 7492	0·436 1101	2·292 999	0·916 6246	0·403 7449	0·441 3132	2·265 964	0·914 8716	45
16	·399 8158	·436 1966	·292 544	·916 5955	·403 8114	·441 4001	·265 518	·914 8422	44
17	·399 8825	·436 2832	·292 089	·916 5664	·403 8780	·441 4870	·265 073	·914 8129	43
18	·399 9492	·436 3697	·291 635	·916 5373	·403 9445	·441 5739	·264 627	·914 7835	42
19	·400 0158	·436 4563	·291 180	·916 5082	·404 0110	·441 6608	·264 181	·914 7541	41
20	0·400 0825	0·436 5429	2·290 726	0·916 4791	0·404 0775	0·441 7477	2·263 736	0·914 7247	40
21	·400 1491	·436 6295	·290 271	·916 4501	·404 1440	·441 8346	·263 290	·914 6954	39
22	·400 2157	·436 7161	·289 817	·916 4209	·404 2106	·441 9215	·262 845	·914 6660	38
23	·400 2824	·436 8027	·289 363	·916 3918	·404 2771	·442 0084	·262 400	·914 6366	37
24	·400 3490	·436 8893	·288 910	·916 3627	·404 3436	·442 0954	·261 955	·914 6072	36
25	0·400 4157	0·436 9759	2·288 456	0·916 3336	0·404 4101	0·442 1823	2·261 511	0·914 5778	35
26	·400 4823	·437 0625	·288 002	·916 3045	·404 4766	·442 2693	·261 066	·914 5483	34
27	·400 5489	·437 1491	·287 549	·916 2754	·404 5431	·442 3562	·260 622	·914 5189	33
28	·400 6156	·437 2357	·287 096	·916 2462	·404 6096	·442 4432	·260 177	·914 4895	32
29	·400 6822	·437 3223	·286 643	·916 2171	·404 6761	·442 5301	·259 733	·914 4601	31
30	0·400 7488	0·437 4090	2·286 190	0·916 1880	0·404 7426	0·442 6171	2·259 289	0·914 4306	30
31	·400 8155	·437 4956	·285 737	·916 1588	·404 8091	·442 7041	·258 845	·914 4012	29
32	·400 8821	·437 5823	·285 285	·916 1297	·404 8756	·442 7910	·258 402	·914 3718	28
33	·400 9487	·437 6689	·284 832	·916 1005	·404 9421	·442 8780	·257 958	·914 3423	27
34	·401 0153	·437 7556	·284 380	·916 0713	·405 0086	·442 9650	·257 515	·914 3129	26
35	0·401 0819	0·437 8422	2·283 928	0·916 0422	0·405 0751	0·443 0520	2·257 071	0·914 2834	25
36	·401 1486	·437 9289	·283 476	·916 0130	·405 1416	·443 1390	·256 628	·914 2540	24
37	·401 2152	·438 0156	·283 024	·915 9838	·405 2081	·443 2260	·256 185	·914 2245	23
38	·401 2818	·438 1022	·282 572	·915 9547	·405 2746	·443 3130	·255 742	·914 1950	22
39	·401 3484	·438 1889	·282 121	·915 9255	·405 3410	·443 4000	·255 300	·914 1655	21
40	0·401 4150	0·438 2756	2·281 669	0·915 8963	0·405 4075	0·443 4871	2·254 857	0·914 1361	20
41	·401 4816	·438 3623	·281 218	·915 8671	·405 4740	·443 5741	·254 415	·914 1066	19
42	·401 5482	·438 4490	·280 767	·915 8379	·405 5405	·443 6611	·253 973	·914 0771	18
43	·401 6148	·438 5357	·280 316	·915 8087	·405 6069	·443 7482	·253 530	·914 0476	17
44	·401 6814	·438 6224	·279 865	·915 7795	·405 6734	·443 8352	·253 089	·914 0181	16
45	0·401 7480	0·438 7091	2·279 415	0·915 7503	0·405 7399	0·443 9223	2·252 647	0·913 9886	15
46	·401 8146	·438 7959	·278 964	·915 7210	·405 8063	·444 0093	·252 205	·913 9591	14
47	·401 8812	·438 8826	·278 514	·915 6918	·405 8728	·444 0964	·251 763	·913 9296	13
48	·401 9478	·438 9693	·278 064	·915 6626	·405 9393	·444 1834	·251 322	·913 9001	12
49	·402 0144	·439 0560	·277 614	·915 6334	·406 0057	·444 2705	·250 881	·913 8705	11
50	0·402 0810	0·439 1428	2·277 164	0·915 6041	0·406 0722	0·444 3576	2·250 440	0·913 8410	10
51	·402 1475	·439 2295	·276 714	·915 5749	·406 1386	·444 4447	·249 999	·913 8115	09
52	·402 2141	·439 3163	·276 264	·915 5456	·406 2051	·444 5318	·249 558	·913 7819	08
53	·402 2807	·439 4031	·275 815	·915 5164	·406 2715	·444 6189	·249 117	·913 7524	07
54	·402 3473	·439 4898	·275 366	·915 4871	·406 3380	·444 7060	·248 677	·913 7228	06
55	0·402 4138	0·439 5766	2·274 916	0·915 4579	0·406 4044	0·444 7931	2·248 236	0·913 6933	05
56	·402 4804	·439 6634	·274 467	·915 4286	·406 4709	·444 8802	·247 796	·913 6637	04
57	·402 5470	·439 7502	·274 019	·915 3993	·406 5373	·444 9673	·247 356	·913 6342	03
58	·402 6136	·439 8369	·273 570	·915 3700	·406 6038	·445 0544	·246 916	·913 6046	02
59	·402 6801	·439 9237	·273 121	·915 3408	·406 6702	·445 1416	·246 476	·913 5750	01
60	0·402 7467	0·440 0105	2·272 673	0·915 3115	0·406 7366	0·445 2287	2·246 037	0·913 5455	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	665–667	868–864	448–458	293–290	664–666	872–868	439–448	296–293	d

$1^h\ 36^m$ $1^h\ 37^m$

d	665–663	871–875	440–431	296–299	663–661	874–879	431–423	298–302	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·406 7366	0·445 2287	2·246 037	0·913 5455	0·410 7189	0·450 4672	2·219 918	0·911 7620	60
01	·406 8031	·445 3158	·245 597	·913 5159	·410 7852	·450 5546	·219 487	·911 7322	59
02	·406 8695	·445 4030	·245 158	·913 4863	·410 8515	·450 6421	·219 056	·911 7023	58
03	·406 9359	·445 4901	·244 719	·913 4567	·410 9178	·450 7296	·218 625	·911 6724	57
04	·407 0024	·445 5773	·244 280	·913 4271	·410 9841	·450 8171	·218 194	·911 6425	56
05	0·407 0688	0·445 6644	2·243 841	0·913 3975	0·411 0504	0·450 9046	2·217 764	0·911 6126	55
06	·407 1352	·445 7516	·243 402	·913 3679	·411 1166	·450 9921	·217 334	·911 5827	54
07	·407 2016	·445 8388	·242 963	·913 3383	·411 1829	·451 0796	·216 903	·911 5528	53
08	·407 2681	·445 9260	·242 525	·913 3087	·411 2492	·451 1672	·216 473	·911 5229	52
09	·407 3345	·446 0132	·242 086	·913 2791	·411 3155	·451 2547	·216 043	·911 4930	51
10	0·407 4009	0·446 1003	2·241 648	0·913 2494	0·411 3818	0·451 3422	2·215 614	0·911 4631	50
11	·407 4673	·446 1875	·241 210	·913 2198	·411 4481	·451 4298	·215 184	·911 4332	49
12	·407 5337	·446 2747	·240 772	·913 1902	·411 5144	·451 5173	·214 754	·911 4033	48
13	·407 6001	·446 3620	·240 334	·913 1605	·411 5806	·451 6049	·214 325	·911 3733	47
14	·407 6665	·446 4492	·239 897	·913 1309	·411 6469	·451 6924	·213 896	·911 3434	46
15	0·407 7329	0·446 5364	2·239 459	0·913 1012	0·411 7132	0·451 7800	2·213 467	0·911 3135	45
16	·407 7993	·446 6236	·239 022	·913 0716	·411 7795	·451 8676	·213 038	·911 2835	44
17	·407 8657	·446 7108	·238 585	·913 0419	·411 8457	·451 9551	·212 609	·911 2536	43
18	·407 9321	·446 7981	·238 147	·913 0123	·411 9120	·452 0427	·212 180	·911 2236	42
19	·407 9985	·446 8853	·237 711	·912 9826	·411 9783	·452 1303	·211 752	·911 1937	41
20	0·408 0649	0·446 9726	2·237 274	0·912 9529	0·412 0445	0·452 2179	2·211 323	0·911 1637	40
21	·408 1313	·447 0598	·236 837	·912 9232	·412 1108	·452 3055	·210 895	·911 1337	39
22	·408 1977	·447 1471	·236 401	·912 8936	·412 1770	·452 3931	·210 467	·911 1038	38
23	·408 2641	·447 2343	·235 964	·912 8639	·412 2433	·452 4807	·210 039	·911 0738	37
24	·408 3305	·447 3216	·235 528	·912 8342	·412 3096	·452 5683	·209 611	·911 0438	36
25	0·408 3968	0·447 4089	2·235 092	0·912 8045	0·412 3758	0·452 6559	2·209 184	0·911 0138	35
26	·408 4632	·447 4962	·234 656	·912 7748	·412 4421	·452 7435	·208 756	·910 9838	34
27	·408 5296	·447 5835	·234 220	·912 7451	·412 5083	·452 8312	·208 329	·910 9538	33
28	·408 5960	·447 6708	·233 785	·912 7154	·412 5745	·452 9188	·207 901	·910 9238	32
29	·408 6623	·447 7581	·233 349	·912 6856	·412 6408	·453 0065	·207 474	·910 8938	31
30	0·408 7287	0·447 8454	2·232 914	0·912 6559	0·412 7070	0·453 0941	2·207 047	0·910 8638	30
31	·408 7951	·447 9327	·232 478	·912 6262	·412 7733	·453 1818	·206 620	·910 8338	29
32	·408 8615	·448 0200	·232 043	·912 5965	·412 8395	·453 2694	·206 193	·910 8038	28
33	·408 9278	·448 1073	·231 608	·912 5667	·412 9057	·453 3571	·205 767	·910 7738	27
34	·408 9942	·448 1946	·231 174	·912 5370	·412 9720	·453 4448	·205 340	·910 7437	26
35	0·409 0605	0·448 2820	2·230 739	0·912 5072	0·413 0382	0·453 5324	2·204 914	0·910 7137	25
36	·409 1269	·448 3693	·230 304	·912 4775	·413 1044	·453 6201	·204 488	·910 6837	24
37	·409 1933	·448 4567	·229 870	·912 4477	·413 1707	·453 7078	·204 062	·910 6536	23
38	·409 2596	·448 5440	·229 436	·912 4180	413 2369	·453 7955	·203 636	·910 6236	22
39	·409 3260	·448 6314	·229 002	·912 3882	·413 3031	·453 8832	·203 210	·910 5935	21
40	0·409 3923	0·448 7187	2·228 568	0·912 3584	0·413 3693	0·453 9709	2·202 784	0·910 5635	20
41	·409 4587	·448 8061	·228 134	·912 3287	·413 4355	·454 0586	·202 359	·910 5334	19
42	·409 5250	·448 8935	·227 700	·912 2989	·413 5018	·454 1463	·201 933	·910 5033	18
43	·409 5914	·448 9808	·227 267	·912 2691	·413 5680	·454 2341	·201 508	·910 4733	17
44	·409 6577	·449 0682	·226 833	·912 2393	·413 6342	·454 3218	·201 083	·910 4432	16
45	0·409 7240	0·449 1556	2·226 400	0·912 2095	0·413 7004	0·454 4095	2·200 658	0·910 4131	15
46	·409 7904	·449 2430	·225 967	·912 1797	·413 7666	·454 4973	·200 233	·910 3830	14
47	·409 8567	·449 3304	·225 534	·912 1499	·413 8328	·454 5850	·199 809	·910 3529	13
48	·409 9230	·449 4178	·225 101	·912 1201	·413 8990	·454 6728	·199 384	·910 3228	12
49	·409 9894	·449 5052	·224 668	·912 0903	·413 9652	·454 7605	·198 960	·910 2927	11
50	0·410 0557	0·449 5927	2·224 236	0·912 0605	0·414 0314	0·454 8483	2·198 535	0·910 2626	10
51	·410 1220	·449 6801	·223 803	·912 0307	·414 0976	·454 9361	·198 111	·910 2325	09
52	·410 1883	·449 7675	·223 371	·912 0008	·414 1638	·455 0238	·197 687	·910 2024	08
53	·410 2547	·449 8549	·222 939	·911 9710	·414 2300	·455 1116	·197 263	·910 1723	07
54	·410 3210	·449 9424	·222 507	·911 9412	·414 2962	·455 1994	·196 839	·910 1421	06
55	0·410 3873	0·450 0298	2·222 075	0·911 9113	0·414 3623	0·455 2872	2·196 416	0·910 1120	05
56	·410 4536	·450 1173	·221 643	·911 8815	·414 4285	·455 3750	·195 992	·910 0819	04
57	·410 5199	·450 2047	·221 212	·911 8516	·414 4947	·455 4628	·195 569	·910 0517	03
58	·410 5862	·450 2922	·220 780	·911 8218	·414 5609	·455 5506	·195 146	·910 0216	02
59	·410 6525	·450 3797	·220 349	·911 7919	·414 6271	·455 6384	·194 723	·909 9914	01
60	0·410 7189	0·450 4672	2·219 918	0·911 7620	0·414 6932	0·455 7263	2·194 300	0·909 9613	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	663–665	875–871	431–440	299–296	661–663	879–874	423–431	302–298	d

$4^h\ 23^m$ $4^h\ 22^m$

$1^h\ 38^m$ $1^h\ 39^m$

d	662–660	878–882	423–415	301–305	661–659	882–886	415–407	304–308	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·414 6932	0·455 7263	2·194 300	0·909 9613	0·418 6597	0·461 0063	2·169 168	0·908 1432	60
01	·414 7594	·455 8141	·193 877	·909 9311	·418 7258	·461 0945	·168 753	·908 1127	59
02	·414 8256	·455 9019	·193 454	·909 9009	·418 7918	·461 1827	·168 338	·908 0823	58
03	·414 8918	·455 9898	·193 032	·909 8708	·418 8579	·461 2709	·167 924	·908 0518	57
04	·414 9579	·456 0776	·192 609	·909 8406	·418 9239	·461 3591	·167 509	·908 0214	56
05	0·415 0241	0·456 1655	2·192 187	0·909 8104	0·418 9899	0·461 4473	2·167 095	0·907 9909	55
06	·415 0902	·456 2533	·191 765	·909 7802	·419 0559	·461 5355	·166 681	·907 9604	54
07	·415 1564	·456 3412	·191 343	·909 7501	·419 1220	·461 6237	·166 267	·907 9299	53
08	·415 2226	·456 4290	·190 921	·909 7199	·419 1880	·461 7119	·165 853	·907 8995	52
09	·415 2887	·456 5169	·190 499	·909 6897	·419 2540	·461 8002	·165 439	·907 8690	51
10	0·415 3549	0·456 6048	2·190 078	0·909 6595	0·419 3200	0·461 8884	2·165 025	0·907 8385	50
11	·415 4210	·456 6927	·189 656	·909 6292	·419 3861	·461 9766	·164 612	·907 8080	49
12	·415 4872	·456 7806	·189 235	·909 5990	·419 4521	·462 0649	·164 198	·907 7775	48
13	·415 5533	·456 8685	·188 814	·909 5688	·419 5181	·462 1531	·163 785	·907 7470	47
14	·415 6195	·456 9564	·188 393	·909 5386	·419 5841	·462 2414	·163 372	·907 7165	46
15	0·415 6856	0·457 0443	2·187 972	0·909 5084	0·419 6501	0·462 3296	2·162 959	0·907 6859	45
16	·415 7517	·457 1322	·187 551	·909 4781	·419 7161	·462 4179	·162 546	·907 6554	44
17	·415 8179	·457 2201	·187 130	·909 4479	·419 7821	·462 5062	·162 133	·907 6249	43
18	·415 8840	·457 3081	·186 710	·909 4177	·419 8481	·462 5945	·161 721	·907 5944	42
19	·415 9502	·457 3960	·186 289	·909 3874	·419 9141	·462 6828	·161 308	·907 5638	41
20	0·416 0163	0·457 4839	2·185 869	0·909 3572	0·419 9801	0·462 7710	2·160 896	0·907 5333	40
21	·416 0824	·457 5719	·185 449	·909 3269	·420 0461	·462 8593	·160 484	·907 5028	39
22	·416 1485	·457 6598	·185 029	·909 2966	·420 1121	·462 9477	·160 071	·907 4722	38
23	·416 2147	·457 7478	·184 609	·909 2664	·420 1781	·463 0360	·159 659	·907 4417	37
24	·416 2808	·457 8357	·184 189	·909 2361	·420 2441	·463 1243	·159 248	·907 4111	36
25	0·416 3469	0·457 9237	2·183 770	0·909 2058	0·420 3101	0·463 2126	2·158 836	0·907 3805	35
26	·416 4130	·458 0117	·183 350	·909 1756	·420 3761	·463 3009	·158 424	·907 3500	34
27	·416 4791	·458 0997	·182 931	·909 1453	·420 4421	·463 3893	·158 013	·907 3194	33
28	·416 5453	·458 1877	·182 512	·909 1150	·420 5080	·463 4776	·157 602	·907 2888	32
29	·416 6114	·458 2756	·182 093	·909 0847	·420 5740	·463 5660	·157 190	·907 2582	31
30	0·416 6775	0·458 3636	2·181 674	0·909 0544	0·420 6400	0·463 6543	2·156 779	0·907 2276	30
31	·416 7436	·458 4516	·181 255	·909 0241	·420 7060	·463 7427	·156 368	·907 1970	29
32	·416 8097	·458 5397	·180 836	·908 9938	·420 7719	·463 8310	·155 958	·907 1665	28
33	·416 8758	·458 6277	·180 418	·908 9635	·420 8379	·463 9194	·155 547	·907 1358	27
34	·416 9419	·458 7157	·180 000	·908 9331	·420 9039	·464 0078	·155 136	·907 1052	26
35	0·417 0080	0·458 8037	2·179 581	0·908 9028	0·420 9699	0·464 0962	2·154 726	0·907 0746	25
36	·417 0741	·458 8918	·179 163	·908 8725	·421 0358	·464 1845	·154 316	·907 0440	24
37	·417 1402	·458 9798	·178 745	·908 8422	·421 1018	·464 2729	·153 905	·907 0134	23
38	·417 2063	·459 0678	·178 327	·908 8118	·421 1677	·464 3613	·153 495	·906 9828	22
39	·417 2724	·459 1559	·177 910	·908 7815	·421 2337	·464 4497	·153 085	·906 9521	21
40	0·417 3385	0·459 2439	2·177 492	0·908 7511	0·421 2996	0·464 5382	2·152 676	0·906 9215	20
41	·417 4045	·459 3320	·177 074	·908 7208	·421 3656	·464 6266	·152 266	·906 8909	19
42	·417 4706	·459 4201	·176 657	·908 6904	·421 4315	·464 7150	·151 857	·906 8602	18
43	·417 5367	·459 5082	·176 240	·908 6601	·421 4975	·464 8034	·151 447	·906 8296	17
44	·417 6028	·459 5962	·175 823	·908 6297	·421 5634	·464 8919	·151 038	·906 7989	16
45	0·417 6689	0·459 6843	2·175 406	0·908 5993	0·421 6294	0·464 9803	2·150 629	0·906 7683	15
46	·417 7349	·459 7724	·174 989	·908 5689	·421 6953	·465 0688	·150 220	·906 7376	14
47	·417 8010	·459 8605	·174 572	·908 5386	·421 7613	·465 1572	·149 811	·906 7069	13
48	·417 8671	·459 9486	·174 156	·908 5082	·421 8272	·465 2457	·149 402	·906 6762	12
49	·417 9331	·460 0367	·173 740	·908 4778	·421 8931	·465 3341	·148 993	·906 6456	11
50	0·417 9992	0·460 1248	2·173 323	0·908 4474	0·421 9591	0·465 4226	2·148 585	0·906 6149	10
51	·418 0653	·460 2130	·172 907	·908 4170	·422 0250	·465 5111	·148 177	·906 5842	09
52	·418 1313	·460 3011	·172 491	·908 3866	·422 0909	·465 5996	·147 768	·906 5535	08
53	·418 1974	·460 3892	·172 075	·908 3562	·422 1568	·465 6881	·147 360	·906 5228	07
54	·418 2634	·460 4774	·171 659	·908 3258	·422 2228	·465 7766	·146 952	·906 4921	06
55	0·418 3295	0·460 5655	2·171 244	0·908 2953	0·422 2887	0·465 8651	2·146 544	0·906 4614	05
56	·418 3956	·460 6537	·170 828	·908 2649	·422 3546	·465 9536	·146 137	·906 4307	04
57	·418 4616	·460 7418	·170 413	·908 2345	·422 4205	·466 0421	·145 729	·906 4000	03
58	·418 5276	·460 8300	·169 998	·908 2041	·422 4864	·466 1306	·145 322	·906 3692	02
59	·418 5937	·460 9181	·169 583	·908 1736	·422 5524	·466 2191	·144 914	·906 3385	01
60	0·418 6597	0·461 0063	2·169 168	0·908 1432	0·422 6183	0·466 3077	2·144 507	0·906 3078	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	660–662	882–878	415–423	305–301	659–661	886–882	407–415	308–304	d

$4^h\ 21^m$ $4^h\ 20^m$

$1^{h}\ 40^{m}$ $1^{h}\ 41^{m}$

d	659–657	885–889	407–400	307–311	658–656	889–893	400–392	310–313	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·422 6183	0·466 3077	2·144 507	0·906 3078	0·426 5687	0·471 6306	2·120 303	0·904 4551	60
01	·422 6842	·466 3962	·144 100	·906 2771	·426 6345	·471 7195	·119 904	·904 4241	59
02	·422 7501	·466 4847	·143 693	·906 2463	·426 7003	·471 8084	·119 504	·904 3931	58
03	·422 8160	·466 5733	·143 286	·906 2156	·426 7661	·471 8973	·119 105	·904 3621	57
04	·422 8819	·466 6618	·142 879	·906 1848	·426 8318	·471 9863	·118 706	·904 3310	56
05	0·422 9478	0·466 7504	2·142 473	0·906 1541	0·426 8976	0·472 0752	2·118 307	0·904 3000	55
06	·423 0137	·466 8390	·142 066	·906 1233	·426 9633	·472 1641	·117 908	·904 2689	54
07	·423 0796	·466 9275	·141 660	·906 0925	·427 0291	·472 2531	·117 509	·904 2379	53
08	·423 1455	·467 0161	·141 254	·906 0618	·427 0949	·472 3420	·117 110	·904 2068	52
09	·423 2113	·467 1047	·140 848	·906 0310	·427 1606	·472 4309	·116 711	·904 1758	51
10	0·423 2772	0·467 1933	2·140 442	0·906 0002	0·427 2264	0·472 5199	2·116 313	0·904 1447	50
11	·423 3431	·467 2819	·140 036	·905 9694	·427 2921	·472 6089	·115 915	·904 1136	49
12	·423 4090	·467 3705	·139 630	·905 9386	·427 3579	·472 6978	·115 516	·904 0825	48
13	·423 4749	·467 4591	·139 224	·905 9078	·427 4236	·472 7868	·115 118	·904 0515	47
14	·423 5408	·467 5477	·138 819	·905 8770	·427 4894	·472 8758	·114 720	·904 0204	46
15	0·423 6066	0·467 6364	2·138 414	0·905 8462	0·427 5551	0·472 9648	2·114 322	0·903 9893	45
16	·423 6725	·467 7250	·138 009	·905 8154	·427 6208	·473 0538	·113 925	·903 9582	44
17	·423 7384	·467 8136	·137 603	·905 7846	·427 6866	·473 1428	·113 527	·903 9271	43
18	·423 8043	·467 9023	·137 198	·905 7538	·427 7523	·473 2318	·113 129	·903 8960	42
19	·423 8701	·467 9909	·136 794	·905 7230	·427 8180	·473 3208	·112 732	·903 8649	41
20	0·423 9360	0·468 0796	2·136 389	0·905 6922	0·427 8838	0·473 4098	2·112 335	0·903 8338	40
21	·424 0018	·468 1682	·135 984	·905 6613	·427 9495	·473 4988	·111 938	·903 8027	39
22	·424 0677	·468 2569	·135 580	·905 6305	·428 0152	·473 5879	·111 541	·903 7715	38
23	·424 1336	·468 3456	·135 176	·905 5996	·428 0809	·473 6769	·111 144	·903 7404	37
24	·424 1994	·468 4342	·134 771	·905 5688	·428 1467	·473 7659	·110 747	·903 7093	36
25	0·424 2653	0·468 5229	2·134 367	0·905 5379	0·428 2124	0·473 8550	2·110 350	0·903 6781	35
26	·424 3311	·468 6116	·133 963	·905 5071	·428 2781	·473 9440	·109 954	·903 6470	34
27	·424 3970	·468 7003	·133 560	·905 4762	·428 3438	·474 0331	·109 557	·903 6158	33
28	·424 4628	·468 7890	·133 156	·905 4454	·428 4095	·474 1222	·109 161	·903 5847	32
29	·424 5287	·468 8777	·132 752	·905 4145	·428 4752	·474 2112	·108 765	·903 5535	31
30	0·424 5945	0·468 9664	2·132 349	0·905 3836	0·428 5409	0·474 3003	2·108 369	0·903 5224	30
31	·424 6604	·469 0551	·131 946	·905 3527	·428 6066	·474 3894	·107 973	·903 4912	29
32	·424 7262	·469 1439	·131 542	·905 3219	·428 6723	·474 4785	·107 577	·903 4600	28
33	·424 7920	·469 2326	·131 139	·905 2910	·428 7380	·474 5676	·107 181	·903 4289	27
34	·424 8579	·469 3213	·130 736	·905 2601	·428 8037	·474 6567	·106 786	·903 3977	26
35	0·424 9237	0·469 4101	2·130 334	0·905 2292	0·428 8694	0·474 7458	2·106 390	0·903 3665	25
36	·424 9895	·469 4988	·129 931	·905 1983	·428 9351	·474 8349	·105 995	·903 3353	24
37	·425 0553	·469 5876	·129 528	·905 1674	·429 0008	·474 9240	·105 600	·903 3041	23
38	·425 1212	·469 6763	·129 126	·905 1364	·429 0665	·475 0132	·105 205	·903 2729	22
39	·425 1870	·469 7651	·128 723	·905 1055	·429 1322	·475 1023	·104 810	·903 2417	21
40	0·425 2528	0·469 8539	2·128 321	0·905 0746	0·429 1979	0·475 1914	2·104 415	0·903 2105	20
41	·425 3186	·469 9427	·127 919	·905 0437	·429 2636	·475 2806	·104 020	·903 1793	19
42	·425 3844	·470 0314	·127 517	·905 0127	·429 3292	·475 3697	·103 626	·903 1480	18
43	·425 4503	·470 1202	·127 115	·904 9818	·429 3949	·475 4589	·103 231	·903 1168	17
44	·425 5161	·470 2090	·126 714	·904 9509	·429 4606	·475 5481	·102 837	·903 0856	16
45	0·425 5819	0·470 2978	2·126 312	0·904 9199	0·429 5263	0·475 6372	2·102 443	0·903 0544	15
46	·425 6477	·470 3866	·125 911	·904 8890	·429 5919	·475 7264	·102 049	·903 0231	14
47	·425 7135	·470 4755	·125 509	·904 8580	·429 6576	·475 8156	·101 655	·902 9919	13
48	·425 7793	·470 5643	·125 108	·904 8271	·429 7233	·475 9048	·101 261	·902 9606	12
49	·425 8451	·470 6531	·124 707	·904 7961	·429 7889	·475 9940	·100 867	·902 9294	11
50	0·425 9109	0·470 7419	2·124 306	0·904 7651	0·429 8546	0·476 0832	2·100 473	0·902 8981	10
51	·425 9767	·470 8308	·123 905	·904 7341	·429 9203	·476 1724	·100 080	·902 8669	09
52	·426 0425	·470 9196	·123 505	·904 7032	·429 9859	·476 2616	·099 686	·902 8356	08
53	·426 1083	·471 0085	·123 104	·904 6722	·430 0516	·476 3508	·099 293	·902 8043	07
54	·426 1741	·471 0973	·122 704	·904 6412	·430 1172	·476 4400	·098 900	·902 7730	06
55	0·426 2398	0·471 1862	2·122 303	0·904 6102	0·430 1829	0·476 5293	2·098 507	0·902 7418	05
56	·426 3056	·471 2751	·121 903	·904 5792	·430 2485	·476 6185	·098 114	·902 7105	04
57	·426 3714	·471 3640	·121 503	·904 5482	·430 3142	·476 7078	·097 721	·902 6792	03
58	·426 4372	·471 4528	·121 103	·904 5172	·430 3798	·476 7970	·097 329	·902 6479	02
59	·426 5030	·471 5417	·120 703	·904 4862	·430 4455	·476 8863	·096 936	·902 6166	01
60	0·426 5687	0·471 6306	2·120 303	0·904 4551	0·430 5111	0·476 9755	2·096 544	0·902 5853	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	657–659	889–885	400–407	311–307	656–658	893–889	392–400	313–310	d

$4^{h}\ 19^{m}$ $4^{h}\ 18^{m}$

$1^{h}\ 42^{m}$ | $1^{h}\ 43^{m}$

d	657–655	892–897	393–385	313–316	655–653	896–900	386–378	316–319	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·430 5111	0·476 9755	2·096 544	0·902 5853	0·434 4453	0·482 3427	2·073 215	0·900 6982	60
01	·430 5767	·477 0648	·096 151	·902 5540	·434 5108	·482 4324	·072 829	·900 6666	59
02	·430 6424	·477 1541	·095 759	·902 5227	·434 5763	·482 5220	·072 444	·900 6350	58
03	·430 7080	·477 2434	·095 367	·902 4913	·434 6417	·482 6117	·072 059	·900 6034	57
04	·430 7736	·477 3326	·094 975	·902 4600	·434 7072	·482 7014	·071 674	·900 5718	56
05	0·430 8393	0·477 4219	2·094 583	0·902 4287	0·434 7727	0·482 7910	2·071 290	0·900 5402	55
06	·430 9049	·477 5112	·094 192	·902 3974	·434 8382	·482 8807	·070 905	·900 5086	54
07	·430 9705	·477 6006	·093 800	·902 3660	·434 9037	·482 9704	·070 520	·900 4770	53
08	·431 0361	·477 6899	·093 408	·902 3347	·434 9692	·483 0601	·070 136	·900 4453	52
09	·431 1017	·477 7792	·093 017	·902 3033	·435 0347	·483 1498	·069 752	·900 4137	51
10	0·431 1674	0·477 8685	2·092 626	0·902 2720	0·435 1001	0·483 2395	2·069 367	0·900 3821	50
11	·431 2330	·477 9578	·092 235	·902 2406	·435 1656	·483 3292	·068 983	·900 3504	49
12	·431 2986	·478 0472	·091 844	·902 2092	·435 2311	·483 4189	·068 599	·900 3188	48
13	·431 3642	·478 1365	·091 453	·902 1779	·435 2966	·483 5086	·068 216	·900 2871	47
14	·431 4298	·478 2259	·091 062	·902 1465	·435 3620	·483 5983	·067 832	·900 2555	46
15	0·431 4954	0·478 3152	2·090 671	0·902 1151	0·435 4275	0·483 6881	2·067 448	0·900 2238	45
16	·431 5610	·478 4046	·090 281	·902 0838	·435 4930	·483 7778	·067 065	·900 1921	44
17	·431 6266	·478 4940	·089 891	·902 0524	·435 5584	·483 8676	·066 681	·900 1605	43
18	·431 6922	·478 5833	·089 500	·902 0210	·435 6239	·483 9573	·066 298	·900 1288	42
19	·431 7578	·478 6727	·089 110	·901 9896	·435 6894	·484 0471	·065 915	·900 0971	41
20	0·431 8234	0·478 7621	2·088 720	0·901 9582	0·435 7548	0·484 1368	2·065 532	0·900 0654	40
21	·431 8890	·478 8515	·088 330	·901 9268	·435 8203	·484 2266	·065 149	·900 0337	39
22	·431 9546	·478 9409	·087 940	·901 8954	·435 8857	·484 3164	·064 766	·900 0020	38
23	·432 0202	·479 0303	·087 551	·901 8639	·435 9512	·484 4062	·064 383	·899 9703	37
24	·432 0857	·479 1197	·087 161	·901 8325	·436 0166	·484 4959	·064 001	·899 9386	36
25	0·432 1513	0·479 2091	2·086 772	0·901 8011	0·436 0821	0·484 5857	2·063 618	0·899 9069	35
26	·432 2169	·479 2986	·086 382	·901 7697	·436 1475	·484 6755	·063 236	·899 8752	34
27	·432 2825	·479 3880	·085 993	·901 7382	·436 2129	·484 7653	·062 854	·899 8435	33
28	·432 3481	·479 4774	·085 604	·901 7068	·436 2784	·484 8552	·062 472	·899 8117	32
29	·432 4136	·479 5669	·085 215	·901 6754	·436 3438	·484 9450	·062 090	·899 7800	31
30	0·432 4792	0·479 6563	2·084 826	0·901 6439	0·436 4092	0·485 0348	2·061 708	0·899 7483	30
31	·432 5448	·479 7458	·084 437	·901 6125	·436 4747	·485 1246	·061 326	·899 7165	29
32	·432 6103	·479 8352	·084 049	·901 5810	·436 5401	·485 2145	·060 944	·899 6848	28
33	·432 6759	·479 9247	·083 660	·901 5495	·436 6055	·485 3043	·060 563	·899 6531	27
34	·432 7415	·480 0142	·083 272	·901 5181	·436 6709	·485 3942	·060 181	·899 6213	26
35	0·432 8070	0·480 1037	2·082 883	0·901 4866	0·436 7364	0·485 4840	2·059 800	0·899 5895	25
36	·432 8726	·480 1932	·082 495	·901 4551	·436 8018	·485 5739	·059 419	·899 5578	24
37	·432 9381	·480 2827	·082 107	·901 4236	·436 8672	·485 6638	·059 038	·899 5260	23
38	·433 0037	·480 3722	·081 719	·901 3921	·436 9326	·485 7537	·058 657	·899 4942	22
39	·433 0692	·480 4617	·081 332	·901 3607	·436 9980	·485 8435	·058 276	·899 4625	21
40	0·433 1348	0·480 5512	2·080 944	0·901 3292	0·437 0634	0·485 9334	2·057 895	0·899 4307	20
41	·433 2003	·480 6407	·080 556	·901 2977	·437 1288	·486 0233	·057 514	·899 3989	19
42	·433 2659	·480 7302	·080 169	·901 2662	·437 1943	·486 1132	·057 134	·899 3671	18
43	·433 3314	·480 8197	·079 781	·901 2346	·437 2597	·486 2031	·056 753	·899 3353	17
44	·433 3970	·480 9093	·079 394	·901 2031	·437 3251	·486 2931	·056 373	·899 3035	16
45	0·433 4625	0·480 9988	2·079 007	0·901 1716	0·437 3905	0·486 3830	2·055 993	0·899 2717	15
46	·433 5280	·481 0884	·078 620	·901 1401	·437 4558	·486 4729	·055 613	·899 2399	14
47	·433 5936	·481 1779	·078 233	·901 1086	·437 5212	·486 5628	·055 233	·899 2081	13
48	·433 6591	·481 2675	·077 847	·901 0770	·437 5866	·486 6528	·054 853	·899 1763	12
49	·433 7246	·481 3571	·077 460	·901 0455	·437 6520	·486 7427	·054 473	·899 1444	11
50	0·433 7901	0·481 4466	2·077 073	0·901 0139	0·437 7174	0·486 8327	2·054 094	0·899 1126	10
51	·433 8557	·481 5362	·076 687	·900 9824	·437 7828	·486 9227	·053 714	·899 0808	09
52	·433 9212	·481 6258	·076 301	·900 9508	·437 8482	·487 0126	·053 335	·899 0489	08
53	·433 9867	·481 7154	·075 915	·900 9193	·437 9136	·487 1026	·052 956	·899 0171	07
54	·434 0522	·481 8050	·075 528	·900 8877	·437 9789	·487 1926	·052 576	·898 9852	06
55	0·434 1177	0·481 8946	2·075 143	0·900 8561	0·438 0443	0·487 2826	2·052 197	0·898 9534	05
56	·434 1832	·481 9842	·074 757	·900 8246	·438 1097	·487 3726	·051 818	·898 9215	04
57	·434 2487	·482 0738	·074 371	·900 7930	·438 1750	·487 4626	·051 440	·898 8897	03
58	·434 3143	·482 1635	·073 985	·900 7614	·438 2404	·487 5526	·051 061	·898 8578	02
59	·434 3798	·482 2531	·073 600	·900 7298	·438 3058	·487 6426	·050 682	·898 8259	01
60	0·434 4453	0·482 3427	2·073 215	0·900 6982	0·438 3711	0·487 7326	2·050 304	0·898 7940	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	655–657	897–892	385–393	316–313	653–655	900–896	378–386	319–316	d

$4^{h}\ 17^{m}$ | $4^{h}\ 16^{m}$

$1^h\ 44^m$ $1^h\ 45^m$

d	654–652	900–904	379–372	318–322	653–650	904–908	372–365	321–325	d
	sin	tan	cot	cos	sin	tan	cot	cos	
s									
00	0·438 3711	0·487 7326	2·050 304	0·898 7940	0·442 2887	0·493 1454	2·027 799	0·896 8727	60
01	·438 4365	·487 8226	·049 925	·898 7622	·442 3539	·493 2358	·027 428	·896 8406	59
02	·438 5019	·487 9126	·049 547	·898 7303	·442 4191	·493 3263	·027 056	·896 8084	58
03	·438 5672	·488 0027	·049 169	·898 6984	·442 4843	·493 4167	·026 685	·896 7762	57
04	·438 6326	·488 0927	·048 791	·898 6665	·442 5496	·493 5071	·026 313	·896 7440	56
05	0·438 6979	0·488 1828	2·048 413	0·898 6346	0·442 6148	0·493 5975	2·025 942	0·896 7119	55
06	·438 7633	·488 2728	·048 035	·898 6027	·442 6800	·493 6880	·025 571	·896 6797	54
07	·438 8286	·488 3629	·047 658	·898 5708	·442 7452	·493 7784	·025 200	·896 6475	53
08	·438 8940	·488 4530	·047 280	·898 5389	·442 8104	·493 8689	·024 829	·896 6153	52
09	·438 9593	·488 5430	·046 903	·898 5069	·442 8756	·493 9594	·024 458	·896 5831	51
10	0·439 0247	0·488 6331	2·046 525	0·898 4750	0·442 9408	0·494 0498	2·024 087	0·896 5509	50
11	·439 0900	·488 7232	·046 148	·898 4431	·443 0060	·494 1403	·023 717	·896 5186	49
12	·439 1553	·488 8133	·045 771	·898 4112	·443 0712	·494 2308	·023 346	·896 4864	48
13	·439 2207	·488 9034	·045 394	·898 3792	·443 1364	·494 3213	·022 976	·896 4542	47
14	·439 2860	·488 9935	·045 017	·898 3473	·443 2016	·494 4118	·022 606	·896 4220	46
15	0·439 3513	0·489 0836	2·044 640	0·898 3153	0·443 2668	0·494 5023	2·022 235	0·896 3897	45
16	·439 4166	·489 1737	·044 263	·898 2834	·443 3319	·494 5928	·021 865	·896 3575	44
17	·439 4820	·489 2639	·043 887	·898 2514	·443 3971	·494 6833	·021 495	·896 3253	43
18	·439 5473	·489 3540	·043 510	·898 2194	·443 4623	·494 7738	·021 126	·896 2930	42
19	·439 6126	·489 4441	·043 134	·898 1875	·443 5275	·494 8643	·020 756	·896 2608	41
20	0·439 6779	0·489 5343	2·042 758	0·898 1555	0·443 5927	0·494 9549	2·020 386	0·896 2285	40
21	·439 7432	·489 6244	·042 382	·898 1235	·443 6578	·495 0454	·020 017	·896 1962	39
22	·439 8086	·489 7146	·042 006	·898 0916	·443 7230	·495 1360	·019 647	·896 1640	38
23	·439 8739	·489 8048	·041 630	·898 0596	·443 7882	·495 2265	·019 278	·896 1317	37
24	·439 9392	·489 8949	·041 254	·898 0276	·443 8534	·495 3171	·018 909	·896 0994	36
25	0·440 0045	0·489 9851	2·040 878	0·897 9956	0·443 9185	0·495 4076	2·018 540	0·896 0672	35
26	·440 0698	·490 0753	·040 503	·897 9636	·443 9837	·495 4982	·018 171	·896 0349	34
27	·440 1351	·490 1655	·040 127	·897 9316	·444 0488	·495 5888	·017 802	·896 0026	33
28	·440 2004	·490 2557	·039 752	·897 8996	·444 1140	·495 6794	·017 433	·895 9703	32
29	·440 2657	·490 3459	·039 377	·897 8676	·444 1792	·495 7700	·017 064	·895 9380	31
30	0·440 3310	0·490 4361	2·039 002	0·897 8355	0·444 2443	0·495 8606	2·016 696	0·895 9057	30
31	·440 3963	·490 5263	·038 627	·897 8035	·444 3095	·495 9512	·016 327	·895 8734	29
32	·440 4615	·490 6166	·038 252	·897 7715	·444 3746	·496 0418	·015 959	·895 8411	28
33	·440 5268	·490 7068	·037 877	·897 7394	·444 4398	·496 1324	·015 591	·895 8087	27
34	·440 5921	·490 7970	·037 502	·897 7074	·444 5049	·496 2230	·015 223	·895 7764	26
35	0·440 6574	0·490 8873	2·037 128	0·897 6754	0·444 5700	0·496 3137	2·014 855	0·895 7441	25
36	·440 7227	·490 9775	·036 753	·897 6433	·444 6352	·496 4043	·014 487	·895 7118	24
37	·440 7880	·491 0678	·036 379	·897 6113	·444 7003	·496 4950	·014 119	·895 6794	23
38	·440 8532	·491 1580	·036 005	·897 5792	·444 7655	·496 5856	·013 751	·895 6471	22
39	·440 9185	·491 2483	·035 630	·897 5471	·444 8306	·496 6763	·013 384	·895 6147	21
40	0·440 9838	0·491 3386	2·035 256	0·897 5151	0·444 8957	0·496 7669	2·013 016	0·895 5824	20
41	·441 0490	·491 4289	·034 883	·897 4830	·444 9608	·496 8576	·012 649	·895 5500	19
42	·441 1143	·491 5191	·034 509	·897 4509	·445 0260	·496 9483	·012 282	·895 5177	18
43	·441 1796	·491 6094	·034 135	·897 4188	·445 0911	·497 0390	·011 915	·895 4853	17
44	·441 2448	·491 6997	·033 762	·897 3868	·445 1562	·497 1297	·011 548	·895 4529	16
45	0·441 3101	0·491 7900	2·033 388	0·897 3547	0·445 2213	0·497 2204	2·011 181	0·895 4206	15
46	·441 3753	·491 8804	·033 015	·897 3226	·445 2864	·497 3111	·010 814	·895 3882	14
47	·441 4406	·491 9707	·032 641	·897 2905	·445 3516	·497 4018	·010 447	·895 3558	13
48	·441 5059	·492 0610	·032 268	·897 2584	·445 4167	·497 4925	·010 081	·895 3234	12
49	·441 5711	·492 1513	·031 895	·897 2263	·445 4818	·497 5832	·009 714	·895 2910	11
50	0·441 6363	0·492 2417	2·031 522	0·897 1941	0·445 5469	0·497 6739	2·009 348	0·895 2586	10
51	·441 7016	·492 3320	·031 150	·897 1620	·445 6120	·497 7647	·008 981	·895 2262	09
52	·441 7668	·492 4224	·030 777	·897 1299	·445 6771	·497 8554	·008 615	·895 1938	08
53	·441 8321	·492 5127	·030 404	·897 0978	·445 7422	·497 9462	·008 249	·895 1614	07
54	·441 8973	·492 6031	·030 032	·897 0656	·445 8073	·498 0369	·007 883	·895 1290	06
55	0·441 9625	0·492 6935	2·029 660	0·897 0335	0·445 8724	0·498 1277	2·007 517	0·895 0965	05
56	·442 0278	·492 7838	·029 287	·897 0014	·445 9375	·498 2185	·007 152	·895 0641	04
57	·442 0930	·492 8742	·028 915	·896 9692	·446 0026	·498 3092	·006 786	·895 0317	03
58	·442 1582	·492 9646	·028 543	·896 9371	·446 0676	·498 4000	·006 420	·894 9992	02
59	·442 2235	·493 0550	·028 171	·896 9049	·446 1327	·498 4908	·006 055	·894 9668	01
60	0·442 2887	0·493 1454	2·027 799	0·896 8727	0·446 1978	0·498 5816	2·005 690	0·894 9344	00
									s
	cos	cot	tan	sin	cos	cot	tan	sin	
d	652–654	904–900	372–379	322–318	650–653	908–904	365–372	325–321	d

$4^h\ 15^m$ $4^h\ 14^m$

$1^{h}\ 46^{m}$ $1^{h}\ 47^{m}$

d	651–649	908–912	366–359	324–328	650–648	912–916	359–352	327–330	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·446 1978	0·498 5816	2·005 690	0·894 9344	0·450 0984	0·504 0415	1·983 964	0·892 9789	60
01	·446 2629	·498 6724	·005 324	·894 9019	·450 1634	·504 1327	·983 605	·892 9462	59
02	·446 3280	·498 7632	·004 959	·894 8695	·450 2283	·504 2239	·983 246	·892 9135	58
03	·446 3930	·498 8540	·004 594	·894 8370	·450 2932	·504 3151	·982 887	·892 8807	57
04	·446 4581	·498 9449	·004 229	·894 8045	·450 3582	·504 4063	·982 529	·892 8480	56
05	0·446 5232	0·499 0357	2·003 865	0·894 7721	0·450 4231	0·504 4976	1·982 170	0·892 8152	55
06	·446 5883	·499 1265	·003 500	·894 7396	·450 4880	·504 5888	·981 812	·892 7825	54
07	·446 6533	·499 2174	·003 135	·894 7071	·450 5530	·504 6800	·981 453	·892 7497	53
08	·446 7184	·499 3082	·002 771	·894 6746	·450 6179	·504 7713	·981 095	·892 7169	52
09	·446 7835	·499 3991	·002 407	·894 6421	·450 6828	·504 8625	·980 737	·892 6842	51
10	0·446 8485	0·499 4899	2·002 042	0·894 6096	0·450 7477	0·504 9538	1·980 379	0·892 6514	50
11	·446 9136	·499 5808	·001 678	·894 5771	·450 8126	·505 0451	·980 021	·892 6186	49
12	·446 9786	·499 6717	·001 314	·894 5446	·450 8775	·505 1363	·979 664	·892 5858	48
13	·447 0437	·499 7626	·000 950	·894 5121	·450 9425	·505 2276	·979 306	·892 5530	47
14	·447 1087	·499 8534	·000 586	·894 4796	·451 0074	·505 3189	·978 948	·892 5202	46
15	0·447 1738	0·499 9443	2·000 223	0·894 4471	0·451 0723	0·505 4102	1·978 591	0·892 4874	45
16	·447 2388	·500 0352	1·999 859	·894 4146	·451 1372	·505 5015	·978 233	·892 4546	44
17	·447 3039	·500 1262	·999 496	·894 3821	·451 2021	·505 5928	·977 876	·892 4218	43
18	·447 3689	·500 2171	·999 132	·894 3495	·451 2670	·505 6841	·977 519	·892 3890	42
19	·447 4339	·500 3080	·998 769	·894 3170	·451 3319	·505 7755	·977 162	·892 3562	41
20	0·447 4990	0·500 3989	1·998 406	0·894 2844	0·451 3967	0·505 8668	1·976 805	0·892 3234	40
21	·447 5640	·500 4899	·998 043	·894 2519	·451 4616	·505 9581	·976 448	·892 2905	39
22	·447 6290	·500 5808	·997 680	·894 2194	·451 5265	·506 0495	·976 091	·892 2577	38
23	·447 6941	·500 6717	·997 317	·894 1868	·451 5914	·506 1408	·975 735	·892 2249	37
24	·447 7591	·500 7627	·996 954	·894 1542	·451 6563	·506 2322	·975 378	·892 1920	36
25	0·447 8241	0·500 8537	1·996 591	0·894 1217	0·451 7212	0·506 3235	1·975 022	0·892 1592	35
26	·447 8891	·500 9446	·996 229	·894 0891	·451 7861	·506 4149	·974 665	·892 1263	34
27	·447 9542	·501 0356	·995 866	·894 0565	·451 8509	·506 5063	·974 309	·892 0935	33
28	·448 0192	·501 1266	·995 504	·894 0240	·451 9158	·506 5977	·973 953	·892 0606	32
29	·448 0842	·501 2176	·995 142	·893 9914	·451 9807	·506 6890	·973 597	·892 0277	31
30	0·448 1492	0·501 3086	1·994 779	0·893 9588	0·452 0455	0·506 7804	1·973 241	0·891 9949	30
31	·448 2142	·501 3996	·994 417	·893 9262	·452 1104	·506 8718	·972 885	·891 9620	29
32	·448 2792	·501 4906	·994 055	·893 8936	·452 1753	·506 9633	·972 530	·891 9291	28
33	·448 3442	·501 5816	·993 694	·893 8610	·452 2401	·507 0547	·972 174	·891 8962	27
34	·448 4092	·501 6726	·993 332	·893 8284	·452 3050	·507 1461	·971 818	·891 8633	26
35	0·448 4742	0·501 7636	1·992 970	0·893 7958	0·452 3699	0·507 2375	1·971 463	0·891 8304	25
36	·448 5392	·501 8547	·992 609	·893 7632	·452 4347	·507 3290	·971 108	·891 7975	24
37	·448 6042	·501 9457	·992 247	·893 7305	·452 4996	·507 4204	·970 752	·891 7646	23
38	·448 6692	·502 0368	·991 886	·893 6979	·452 5644	·507 5118	·970 397	·891 7317	22
39	·448 7342	·502 1278	·991 525	·893 6653	·452 6293	·507 6033	·970 042	·891 6988	21
40	0·448 7992	0·502 2189	1·991 164	0·893 6326	0·452 6941	0·507 6948	1·969 687	0·891 6659	20
41	·448 8642	·502 3099	·990 803	·893 6000	·452 7589	·507 7862	·969 333	·891 6330	19
42	·448 9291	·502 4010	·990 442	·893 5674	·452 8238	·507 8777	·968 978	·891 6000	18
43	·448 9941	·502 4921	·990 081	·893 5347	·452 8886	·507 9692	·968 623	·891 5671	17
44	·449 0591	·502 5832	·989 720	·893 5021	·452 9535	·508 0607	·968 269	·891 5342	16
45	0·449 1241	0·502 6743	1·989 360	0·893 4694	0·453 0183	0·508 1522	1·967 914	0·891 5012	15
46	·449 1891	·502 7654	·988 999	·893 4367	·453 0831	·508 2437	·967 560	·891 4683	14
47	·449 2540	·502 8565	·988 639	·893 4041	·453 1480	·508 3352	·967 206	·891 4353	13
48	·449 3190	·502 9476	·988 279	·893 3714	·453 2128	·508 4267	·966 852	·891 4024	12
49	·449 3840	·503 0387	·987 919	·893 3387	·453 2776	·508 5182	·966 498	·891 3694	11
50	0·449 4489	0·503 1299	1·987 558	0·893 3060	0·453 3424	0·508 6098	1·966 144	0·891 3364	10
51	·449 5139	·503 2210	·987 199	·893 2733	·453 4072	·508 7013	·965 790	·891 3035	09
52	·449 5789	·503 3121	·986 839	·893 2406	·453 4721	·508 7929	·965 436	·891 2705	08
53	·449 6438	·503 4033	·986 479	·893 2080	·453 5369	·508 8844	·965 083	·891 2375	07
54	·449 7088	·503 4944	·986 119	·893 1753	·453 6017	·508 9760	·964 729	·891 2045	06
55	0·449 7737	0·503 5856	1·985 760	0·893 1425	0·453 6665	0·509 0675	1·964 376	0·891 1715	05
56	·449 8387	·503 6768	·985 400	·893 1098	·453 7313	·509 1591	·964 023	·891 1385	04
57	·449 9036	·503 7679	·985 041	·893 0771	·453 7961	·509 2507	·963 669	·891 1055	03
58	·449 9686	·503 8591	·984 682	·893 0444	·453 8609	·509 3423	·963 316	·891 0725	02
59	·450 0335	·503 9503	·984 323	·893 0117	·453 9257	·509 4339	·962 963	·891 0395	01
60	0·450 0984	0·504 0415	1·983 964	0·892 9789	0·453 9905	0·509 5254	1·962 611	0·891 0065	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	649–651	912–908	359–366	328–324	648–650	916–912	352–359	330–327	d

$4^{h}\ 13^{m}$ $4^{h}\ 12^{m}$

$1^{h}\ 48^{m}$ $1^{h}\ 49^{m}$

d	648–646	916–920	353–347	330–333	647–645	920–925	347–341	333–336	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·453 9905	0·509 5254	1·962 611	0·891 0065	0·457 8739	0·515 0338	1·941 620	0·889 0171	60
01	·454 0553	·509 6171	·962 258	·890 9735	·457 9386	·515 1259	·941 273	·888 9838	59
02	·454 1201	·509 7087	·961 905	·890 9405	·458 0032	·515 2179	·940 926	·888 9505	58
03	·454 1849	·509 8003	·961 552	·890 9075	·458 0679	·515 3099	·940 580	·888 9172	57
04	·454 2497	·509 8919	·961 200	·890 8744	·458 1325	·515 4019	·940 233	·888 8839	56
05	0·454 3144	0·509 9835	1·960 848	0·890 8414	0·458 1971	0·515 4940	1·939 887	0·888 8506	55
06	·454 3792	·510 0752	·960 495	·890 8083	·458 2618	·515 5860	·939 540	·888 8173	54
07	·454 4440	·510 1668	·960 143	·890 7753	·458 3264	·515 6781	·939 194	·888 7839	53
08	·454 5088	·510 2585	·959 791	·890 7423	·458 3910	·515 7702	·938 848	·888 7506	52
09	·454 5736	·510 3501	·959 439	·890 7092	·458 4557	·515 8622	·938 502	·888 7173	51
10	0·454 6383	0·510 4418	1·959 087	0·890 6761	0·458 5203	0·515 9543	1·938 156	0·888 6839	50
11	·454 7031	·510 5335	·958 735	·890 6431	·458 5849	·516 0464	·937 810	·888 6506	49
12	·454 7679	·510 6252	·958 384	·890 6100	·458 6496	·516 1385	·937 465	·888 6172	48
13	·454 8326	·510 7168	·958 032	·890 5769	·458 7142	·516 2306	·937 119	·888 5839	47
14	·454 8974	·510 8085	·957 681	·890 5439	·458 7788	·516 3227	·936 773	·888 5505	46
15	0·454 9622	0·510 9002	1·957 329	0·890 5108	0·458 8434	0·516 4148	1·936 428	0·888 5171	45
16	·455 0269	·510 9919	·956 978	·890 4777	·458 9080	·516 5069	·936 082	·888 4838	44
17	·455 0917	·511 0837	·956 627	·890 4446	·458 9726	·516 5990	·935 737	·888 4504	43
18	·455 1564	·511 1754	·956 276	·890 4115	·459 0372	·516 6912	·935 392	·888 4170	42
19	·455 2212	·511 2671	·955 925	·890 3784	·459 1018	·516 7833	·935 047	·888 3836	41
20	0·455 2859	0·511 3588	1·955 574	0·890 3453	0·459 1665	0·516 8755	1·934 702	0·888 3503	40
21	·455 3507	·511 4506	·955 223	·890 3122	·459 2311	·516 9676	·934 357	·888 3169	39
22	·455 4154	·511 5423	·954 872	·890 2791	·459 2957	·517 0598	·934 012	·888 2835	38
23	·455 4802	·511 6341	·954 522	·890 2459	·459 3603	·517 1520	·933 668	·888 2501	37
24	·455 5449	·511 7259	·954 171	·890 2128	·459 4248	·517 2441	·933 323	·888 2166	36
25	0·455 6096	0·511 8176	1·953 821	0·890 1797	0·459 4894	0·517 3363	1·932 979	0·888 1832	35
26	·455 6744	·511 9094	·953 471	·890 1465	·459 5540	·517 4285	·932 634	·888 1498	34
27	·455 7391	·512 0012	·953 120	·890 1134	·459 6186	·517 5207	·932 290	·888 1164	33
28	·455 8038	·512 0930	·952 770	·890 0803	·459 6832	·517 6129	·931 946	·888 0830	32
29	·455 8686	·512 1848	·952 420	·890 0471	·459 7478	·517 7051	·931 602	·888 0495	31
30	0·455 9333	0·512 2766	1·952 071	0·890 0140	0·459 8124	0·517 7973	1·931 258	0·888 0161	30
31	·455 9980	·512 3684	·951 721	·889 9808	·459 8769	·517 8895	·930 914	·887 9827	29
32	·456 0627	·512 4602	·951 371	·889 9476	·459 9415	·517 9818	·930 570	·887 9492	28
33	·456 1275	·512 5520	·951 021	·889 9145	·460 0061	·518 0740	·930 226	·887 9158	27
34	·456 1922	·512 6438	·950 672	·889 8813	·460 0707	·518 1663	·929 883	·887 8823	26
35	0·456 2569	0·512 7357	1·950 323	0·889 8481	0·460 1352	0·518 2585	1·929 539	0·887 8488	25
36	·456 3216	·512 8275	·949 973	·889 8149	·460 1998	·518 3508	·929 196	·887 8154	24
37	·456 3863	·512 9194	·949 624	·889 7817	·460 2643	·518 4430	·928 852	·887 7819	23
38	·456 4510	·513 0112	·949 275	·889 7485	·460 3289	·518 5353	·928 509	·887 7484	22
39	·456 5157	·513 1031	·948 926	·889 7154	·460 3935	·518 6276	·928 166	·887 7150	21
40	0·456 5804	0·513 1950	1·948 577	0·889 6822	0·460 4580	0·518 7199	1·927 823	0·887 6815	20
41	·456 6451	·513 2869	·948 228	·889 6489	·460 5226	·518 8122	·927 480	·887 6480	19
42	·456 7098	·513 3787	·947 880	·889 6157	·460 5871	·518 9045	·927 137	·887 6145	18
43	·456 7745	·513 4706	·947 531	·889 5825	·460 6517	·518 9968	·926 794	·887 5810	17
44	·456 8392	·513 5625	·947 183	·889 5493	·460 7162	·519 0891	·926 452	·887 5475	16
45	0·456 9039	0·513 6544	1·946 834	0·889 5161	0·460 7808	0·519 1814	1·926 109	0·887 5140	15
46	·456 9686	·513 7463	·946 486	·889 4828	·460 8453	·519 2737	·925 767	·887 4805	14
47	·457 0332	·513 8383	·946 138	·889 4496	·460 9098	·519 3661	·925 424	·887 4470	13
48	·457 0979	·513 9302	·945 790	·889 4164	·460 9744	·519 4584	·925 082	·887 4134	12
49	·457 1626	·514 0221	·945 442	·889 3831	·461 0389	·519 5508	·924 740	·887 3799	11
50	0·457 2273	0·514 1141	1·945 094	0·889 3499	0·461 1034	0·519 6431	1·924 398	0·887 3464	10
51	·457 2920	·514 2060	·944 746	·889 3166	·461 1680	·519 7355	·924 056	·887 3129	09
52	·457 3566	·514 2980	·944 398	·889 2834	·461 2325	·519 8278	·923 714	·887 2793	08
53	·457 4213	·514 3899	·944 051	·889 2501	·461 2970	·519 9202	·923 372	·887 2458	07
54	·457 4860	·514 4819	·943 703	·889 2168	·461 3615	·520 0126	·923 030	·887 2122	06
55	0·457 5506	0·514 5739	1·943 356	0·889 1836	0·461 4261	0·520 1050	1·922 689	0·887 1787	05
56	·457 6153	·514 6658	·943 008	·889 1503	·461 4906	·520 1974	·922 347	·887 1451	04
57	·457 6800	·514 7578	·942 661	·889 1170	·461 5551	·520 2898	·922 006	·887 1115	03
58	·457 7446	·514 8498	·942 314	·889 0837	·461 6196	·520 3822	·921 664	·887 0780	02
59	·457 8093	·514 9418	·941 967	·889 0504	·461 6841	·520 4746	·921 323	·887 0444	01
60	0·457 8739	0·515 0338	1·941 620	0·889 0171	0·461 7486	0·520 5671	1·920 982	0·887 0108	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	646–648	920–916	347–353	333–330	645–647	925–920	341–347	336–333	d

$4^{h}\ 11^{m}$ $4^{h}\ 10^{m}$

	$1^h\ 50^m$				$1^h\ 51^m$				
d	645–643	924–929	341–335	335–339	644–642	928–933	336–330	338–342	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·461 7486	0·520 5671	1·920 982	0·887 0108	0·465 6145	0·526 1255	1·900 687	0·884 9876	60
01	·461 8131	·520 6595	·920 641	·886 9773	·465 6789	·526 2183	·900 352	·884 9538	59
02	·461 8776	·520 7519	·920 300	·886 9437	·465 7432	·526 3112	·900 017	·884 9199	58
03	·461 9421	·520 8444	·919 959	·886 9101	·465 8076	·526 4040	·899 681	·884 8860	57
04	·462 0066	·520 9368	·919 619	·886 8765	·465 8719	·526 4969	·899 346	·884 8522	56
05	0·462 0711	0·521 0293	1·919 278	0·886 8429	0·465 9363	0·526 5898	1·899 011	0·884 8183	55
06	·462 1356	·521 1218	·918 937	·886 8093	·466 0006	·526 6827	·898 676	·884 7844	54
07	·462 2001	·521 2142	·918 597	·886 7757	·466 0650	·526 7756	·898 342	·884 7505	53
08	·462 2646	·521 3067	·918 257	·886 7420	·466 1293	·526 8685	·898 007	·884 7166	52
09	·462 3291	·521 3992	·917 916	·886 7084	·466 1936	·526 9614	·897 672	·884 6827	51
10	0·462 3935	0·521 4917	1·917 576	0·886 6748	0·466 2580	0·527 0543	1·897 338	0·884 6488	50
11	·462 4580	·521 5842	·917 236	·886 6412	·466 3223	·527 1473	·897 003	·884 6149	49
12	·462 5225	·521 6767	·916 896	·886 6075	·466 3866	·527 2402	·896 669	·884 5810	48
13	·462 5870	·521 7692	·916 556	·886 5739	·466 4510	·527 3331	·896 334	·884 5471	47
14	·462 6514	·521 8617	·916 216	·886 5403	·466 5153	·527 4261	·896 000	·884 5131	46
15	0·462 7159	0·521 9543	1·915 877	0·886 5066	0·466 5796	0·527 5190	1·895 666	0·884 4792	45
16	·462 7804	·522 0468	·915 537	·886 4730	·466 6439	·527 6120	·895 332	·884 4453	44
17	·462 8448	·522 1394	·915 198	·886 4393	·466 7083	·527 7050	·894 998	·884 4113	43
18	·462 9093	·522 2319	·914 858	·886 4056	·466 7726	·527 7979	·894 664	·884 3774	42
19	·462 9738	·522 3245	·914 519	·886 3720	·466 8369	·527 8909	·894 331	·884 3434	41
20	0·463 0382	0·522 4170	1·914 180	0·886 3383	0·466 9012	0·527 9839	1·893 997	0·884 3095	40
21	·463 1027	·522 5096	·913 840	·886 3046	·466 9655	·528 0769	·893 664	·884 2755	39
22	·463 1671	·522 6022	·913 501	·886 2710	·467 0298	·528 1699	·893 330	·884 2416	38
23	·463 2316	·522 6948	·913 162	·886 2373	·467 0941	·528 2629	·892 997	·884 2076	37
24	·463 2960	·522 7874	·912 824	·886 2036	·467 1584	·528 3560	·892 663	·884 1736	36
25	0·463 3605	0·522 8800	1·912 485	0·886 1699	0·467 2227	0·528 4490	1·892 330	0·884 1397	35
26	·463 4249	·522 9726	·912 146	·886 1362	·467 2870	·528 5420	·891 997	·884 1057	34
27	·463 4894	·523 0652	·911 808	·886 1025	·467 3513	·528 6351	·891 664	·884 0717	33
28	·463 5538	·523 1578	·911 469	·886 0688	·467 4156	·528 7281	·891 331	·884 0377	32
29	·463 6182	·523 2504	·911 131	·886 0351	·467 4799	·528 8212	·890 998	·884 0037	31
30	0·463 6827	0·523 3431	1·910 792	0·886 0013	0·467 5442	0·528 9142	1·890 666	0·883 9697	30
31	·463 7471	·523 4357	·910 454	·885 9676	·467 6084	·529 0073	·890 333	·883 9357	29
32	·463 8115	·523 5284	·910 116	·885 9339	·467 6727	·529 1004	·890 001	·883 9017	28
33	·463 8760	·523 6210	·909 778	·885 9002	·467 7370	·529 1935	·889 668	·883 8677	27
34	·463 9404	·523 7137	·909 440	·885 8664	·467 8013	·529 2865	·889 336	·883 8337	26
35	0·464 0048	0·523 8064	1·909 102	0·885 8327	0·467 8655	0·529 3796	1·889 004	0·883 7997	25
36	·464 0692	·523 8990	·908 765	·885 7989	·467 9298	·529 4727	·888 671	·883 7656	24
37	·464 1336	·523 9917	·908 427	·885 7652	·467 9941	·529 5659	·888 339	·883 7316	23
38	·464 1980	·524 0844	·908 090	·885 7314	·468 0583	·529 6590	·888 007	·883 6976	22
39	·464 2625	·524 1771	·907 752	·885 6977	·468 1226	·529 7521	·887 675	·883 6635	21
40	0·464 3269	0·524 2698	1·907 415	0·885 6639	0·468 1869	0·529 8452	1·887 344	0·883 6295	20
41	·464 3913	·524 3625	·907 077	·885 6301	·468 2511	·529 9384	·887 012	·883 5954	19
42	·464 4557	·524 4553	·906 740	·885 5964	·468 3154	·530 0315	·886 680	·883 5614	18
43	·464 5201	·524 5480	·906 403	·885 5626	·468 3796	·530 1247	·886 349	·883 5273	17
44	·464 5845	·524 6407	·906 066	·885 5288	·468 4439	·530 2178	·886 017	·883 4933	16
45	0·464 6489	0·524 7335	1·905 729	0·885 4950	0·468 5081	0·530 3110	1·885 686	0·883 4592	15
46	·464 7133	·524 8262	·905 393	·885 4612	·468 5724	·530 4042	·885 355	·883 4251	14
47	·464 7777	·524 9190	·905 056	·885 4274	·468 6366	·530 4974	·885 023	·883 3910	13
48	·464 8420	·525 0117	·904 719	·885 3936	·468 7009	·530 5906	·884 692	·883 3569	12
49	·464 9064	·525 1045	·904 383	·885 3598	·468 7651	·530 6838	·884 361	·883 3229	11
50	0·464 9708	0·525 1973	1·904 046	0·885 3260	0·468 8293	0·530 7770	1·884 030	0·883 2888	10
51	·465 0352	·525 2901	·903 710	·885 2922	·468 8936	·530 8702	·883 700	·883 2547	09
52	·465 0996	·525 3829	·903 374	·885 2584	·468 9578	·530 9634	·883 369	·883 2206	08
53	·465 1640	·525 4757	·903 038	·885 2245	·469 0220	·531 0566	·883 038	·883 1865	07
54	·465 2283	·525 5685	·902 702	·885 1907	·469 0863	·531 1499	·882 708	·883 1524	06
55	0·465 2927	0·525 6613	1·902 366	0·885 1569	0·469 1505	0·531 2431	1·882 377	0·883 1182	05
56	·465 3571	·525 7541	·902 030	·885 1230	·469 2147	·531 3364	·882 047	·883 0841	04
57	·465 4214	·525 8469	·901 694	·885 0892	·469 2789	·531 4296	·881 717	·883 0500	03
58	·465 4858	·525 9398	·901 358	·885 0553	·469 3431	·531 5229	·881 387	·883 0159	02
59	·465 5502	·526 0326	·901 023	·885 0215	·469 4074	·531 6162	·881 056	·882 9817	01
60	0·465 6145	0·526 1255	1·900 687	0·884 9876	0·469 4716	0·531 7094	1·880 726	0·882 9476	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	643–645	929–924	335–341	339–335	642–644	933–928	330–336	342–338	d
	$4^h\ 09^m$				$4^h\ 08^m$				

$1^{h}\ 52^{m}$ $1^{h}\ 53^{m}$

d	642–640	933–937	330–324	341–345	641–639	937–942	325–319	344–347	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·469 4716	0·531 7094	1·880 726	0·882 9476	0·473 3197	0·537 3194	1·861 091	0·880 8907	60
01	·469 5358	·531 8027	·880 397	·882 9134	·473 3837	·537 4131	·860 766	·880 8563	59
02	·469 6000	·531 8960	·880 067	·882 8793	·473 4478	·537 5068	·860 441	·880 8219	58
03	·469 6642	·531 9893	·879 737	·882 8451	·473 5118	·537 6006	·860 117	·880 7875	57
04	·469 7284	·532 0826	·879 407	·882 8110	·473 5759	·537 6943	·859 793	·880 7530	56
05	0·469 7926	0·532 1759	1·879 078	0·882 7768	0·473 6399	0·537 7881	1·859 469	0·880 7186	55
06	·469 8568	·532 2693	·878 748	·882 7427	·473 7040	·537 8818	·859 144	·880 6841	54
07	·469 9210	·532 3626	·878 419	·882 7085	·473 7680	·537 9756	·858 820	·880 6497	53
08	·469 9852	·532 4559	·878 090	·882 6743	·473 8321	·538 0694	·858 496	·880 6152	52
09	·470 0494	·532 5493	·877 761	·882 6401	·473 8961	·538 1631	·858 173	·880 5808	51
10	0·470 1135	0·532 6426	1·877 431	0·882 6060	0·473 9601	0·538 2569	1·857 849	0·880 5463	50
11	·470 1777	·532 7360	·877 102	·882 5718	·474 0242	·538 3507	·857 525	·880 5118	49
12	·470 2419	·532 8293	·876 774	·882 5376	·474 0882	·538 4445	·857 202	·880 4774	48
13	·470 3061	·532 9227	·876 445	·882 5034	·474 1522	·538 5383	·856 878	·880 4429	47
14	·470 3703	·533 0161	·876 116	·882 4692	·474 2163	·538 6321	·856 555	·880 4084	46
15	0·470 4344	0·533 1095	1·875 787	0·882 4350	0·474 2803	0·538 7260	1·856 231	0·880 3739	45
16	·470 4986	·533 2029	·875 459	·882 4007	·474 3443	·538 8198	·855 908	·880 3394	44
17	·470 5628	·533 2963	·875 130	·882 3665	·474 4083	·538 9136	·855 585	·880 3049	43
18	·470 6269	·533 3897	·874 802	·882 3323	·474 4723	·539 0075	·855 262	·880 2704	42
19	·470 6911	·533 4831	·874 474	·882 2981	·474 5364	·539 1013	·854 939	·880 2359	41
20	0·470 7553	0·533 5765	1·874 145	0·882 2638	0·474 6004	0·539 1952	1·854 616	0·880 2014	40
21	·470 8194	·533 6699	·873 817	·882 2296	·474 6644	·539 2891	·854 293	·880 1669	39
22	·470 8836	·533 7634	·873 489	·882 1954	·474 7284	·539 3829	·853 970	·880 1324	38
23	·470 9477	·533 8568	·873 161	·882 1611	·474 7924	·539 4768	·853 648	·880 0978	37
24	·471 0119	·533 9503	·872 834	·882 1269	·474 8564	·539 5707	·853 325	·880 0633	36
25	0·471 0760	0·534 0437	1·872 506	0·882 0926	0·474 9204	0·539 6646	1·853 003	0·880 0288	35
26	·471 1402	·534 1372	·872 178	·882 0584	·474 9844	·539 7585	·852 680	·879 9942	34
27	·471 2043	·534 2307	·871 851	·882 0241	·475 0484	·539 8524	·852 358	·879 9597	33
28	·471 2685	·534 3242	·871 523	·881 9898	·475 1124	·539 9464	·852 036	·879 9251	32
29	·471 3326	·534 4176	·871 196	·881 9555	·475 1764	·540 0403	·851 714	·879 8906	31
30	0·471 3967	0·534 5111	1·870 868	0·881 9213	0·475 2403	0·540 1342	1·851 392	0·879 8560	30
31	·471 4609	·534 6046	·870 541	·881 8870	·475 3043	·540 2282	·851 070	·879 8215	29
32	·471 5250	·534 6981	·870 214	·881 8527	·475 3683	·540 3221	·850 748	·879 7869	28
33	·471 5891	·534 7917	·869 887	·881 8184	·475 4323	·540 4161	·850 426	·879 7523	27
34	·471 6533	·534 8852	·869 560	·881 7841	·475 4963	·540 5100	·850 104	·879 7177	26
35	0·471 7174	0·534 9787	1·869 233	0·881 7498	0·475 5602	0·540 6040	1·849 783	0·879 6832	25
36	·471 7815	·535 0723	·868 906	·881 7155	·475 6242	·540 6980	·849 461	·879 6486	24
37	·471 8456	·535 1658	·868 580	·881 6812	·475 6882	·540 7920	·849 140	·879 6140	23
38	·471 9097	·535 2594	·868 253	·881 6469	·475 7521	·540 8860	·848 819	·879 5794	22
39	·471 9739	·535 3529	·867 927	·881 6125	·475 8161	·540 9800	·848 497	·879 5448	21
40	0·472 0380	0·535 4465	1·867 600	0·881 5782	0·475 8801	0·541 0740	1·848 176	0·879 5102	20
41	·472 1021	·535 5401	·867 274	·881 5439	·475 9440	·541 1680	·847 855	·879 4756	19
42	·472 1662	·535 6336	·866 948	·881 5096	·476 0080	·541 2620	·847 534	·879 4410	18
43	·472 2303	·535 7272	·866 622	·881 4752	·476 0719	·541 3560	·847 213	·879 4063	17
44	472 2944	·535 8208	·866 295	·881 4409	·476 1359	·541 4501	·846 892	·879 3717	16
45	0·472 3585	0·535 9144	1·865 970	0·881 4065	0·476 1998	0·541 5441	1·846 572	0·879 3371	15
46	·472 4226	·536 0080	·865 644	·881 3722	·476 2638	·541 6382	·846 251	·879 3025	14
47	·472 4867	·536 1017	·865 318	·881 3378	·476 3277	·541 7322	·845 930	·879 2678	13
48	·472 5508	·536 1953	·864 992	·881 3035	·476 3917	·541 8263	·845 610	·879 2332	12
49	·472 6149	·536 2889	·864 666	·881 2691	·476 4556	·541 9204	·845 290	·879 1985	11
50	0·472 6789	0·536 3826	1·864 341	0·881 2347	0·476 5195	0·542 0145	1·844 969	0·879 1639	10
51	·472 7430	·536 4762	·864 016	·881 2003	·476 5835	·542 1086	·844 649	·879 1292	09
52	·472 8071	·536 5699	·863 690	·881 1660	·476 6474	·542 2027	·844 329	·879 0946	08
53	·472 8712	·536 6635	·863 365	·881 1316	·476 7113	·542 2968	·844 009	·879 0599	07
54	·472 9353	536 7572	·863 040	·881 0972	·476 7753	·542 3909	·843 689	·879 0252	06
55	0·472 9993	0·536 8509	1·862 715	0·881 0628	0·476 8392	0·542 4850	1·843 369	0·878 9906	05
56	·473 0634	·536 9446	·862 390	·881 0284	·476 9031	·542 5791	·843 049	·878 9559	04
57	·473 1275	·537 0383	·862 065	·880 9940	·476 9670	·542 6733	·842 729	·878 9212	03
58	·473 1915	·537 1320	·861 740	·880 9596	·477 0309	·542 7674	·842 410	·878 8865	02
59	·473 2556	·537 2257	·861 415	·880 9252	·477 0948	·542 8615	·842 090	·878 8518	01
60	0·473 3197	0·537 3194	1·861 091	0·880 8907	0·477 1588	0·542 9557	1·841 771	0·878 8171	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	640–642	937–933	324–330	345–341	639–641	942–937	319–325	347–344	d

$4^{h}\ 07^{m}$ $4^{h}\ 06^{m}$

1h 54m **1h 55m**

d	639–637	941–946	320–314	347–350	638–636	946–951	314–309	350–353	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·477 1588	0·542 9557	1·841 771	0·878 8171	0·480 9888	0·548 6188	1·822 759	0·876 7268	60
01	·477 2227	·543 0499	·841 452	·878 7824	·481 0525	·548 7134	·822 445	·876 6918	59
02	·477 2866	·543 1440	·841 132	·878 7477	·481 1163	·548 8080	·822 131	·876 6568	58
03	·477 3505	·543 2382	·840 813	·878 7130	·481 1800	·548 9027	·821 817	·876 6218	57
04	·477 4144	·543 3324	·840 494	·878 6783	·481 2438	·548 9973	·821 503	·876 5868	56
05	0·477 4783	0·543 4266	1·840 175	0·878 6436	0·481 3075	0·549 0919	1·821 189	0·876 5518	55
06	·477 5422	·543 5208	·839 856	·878 6088	·481 3713	·549 1866	·820 875	·876 5168	54
07	·477 6061	·543 6150	·839 537	·878 5741	·481 4350	·549 2812	·820 561	·876 4818	53
08	·477 6700	·543 7092	·839 218	·878 5394	·481 4987	·549 3759	·820 247	·876 4468	52
09	·477 7338	·543 8034	·838 900	·878 5046	·481 5625	·549 4706	·819 934	·876 4118	51
10	0·477 7977	0·543 8977	1·838 581	0·878 4699	0·481 6262	0·549 5653	1·819 620	0·876 3767	50
11	·477 8616	·543 9919	·838 263	·878 4351	·481 6899	·549 6600	·819 307	·876 3417	49
12	·477 9255	·544 0862	·837 944	·878 4004	·481 7537	·549 7547	·818 993	·876 3067	48
13	·477 9894	·544 1804	·837 626	·878 3656	·481 8174	·549 8494	·818 680	·876 2716	47
14	·478 0532	·544 2747	·837 308	·878 3309	·481 8811	·549 9441	·818 367	·876 2366	46
15	0·478 1171	0·544 3689	1·836 989	0·878 2961	0·481 9448	0·550 0388	1·818 054	0·876 2016	45
16	·478 1810	·544 4632	·836 671	·878 2613	·482 0086	·550 1335	·817 741	·876 1665	44
17	·478 2449	·544 5575	·836 353	·878 2265	·482 0723	·550 2283	·817 428	·876 1315	43
18	·478 3087	·544 6518	·836 035	·878 1918	·482 1360	·550 3230	·817 115	·876 0964	42
19	·478 3726	·544 7461	·835 718	·878 1570	·482 1997	·550 4177	·816 802	·876 0613	41
20	0·478 4364	0·544 8404	1·835 400	0·878 1222	0·482 2634	0·550 5125	1·816 489	0·876 0263	40
21	·478 5003	·544 9347	·835 082	·878 0874	·482 3271	·550 6073	·816 177	·875 9912	39
22	·478 5642	·545 0290	·834 765	·878 0526	·482 3908	·550 7020	·815 864	·875 9561	38
23	·478 6280	·545 1234	·834 447	·878 0178	·482 4545	·550 7968	·815 552	·875 9210	37
24	·478 6919	·545 2177	·834 130	·877 9830	·482 5182	·550 8916	·815 239	·875 8859	36
25	0·478 7557	0·545 3120	1·833 812	0·877 9482	0·482 5819	0·550 9864	1·814 927	0·875 8508	35
26	·478 8196	·545 4064	·833 495	·877 9133	·482 6456	·551 0812	·814 615	·875 8157	34
27	·478 8834	·545 5008	·833 178	·877 8785	·482 7093	·551 1760	·814 302	·875 7806	33
28	·478 9472	·545 5951	·832 861	·877 8437	·482 7730	·551 2708	·813 990	·875 7455	32
29	·479 0111	·545 6895	·832 544	·877 8089	·482 8367	·551 3657	·813 678	·875 7104	31
30	0·479 0749	0·545 7839	1·832 227	0·877 7740	0·482 9003	0·551 4605	1·813 367	0·875 6753	30
31	·479 1387	·545 8783	·831 910	·877 7392	·482 9640	·551 5553	·813 055	·875 6402	29
32	·479 2026	·545 9727	·831 594	·877 7043	·483 0277	·551 6502	·812 743	·875 6051	28
33	·479 2664	·546 0671	·831 277	·877 6695	·483 0914	·551 7450	·812 431	·875 5699	27
34	·479 3302	·546 1615	·830 960	·877 6346	·483 1550	·551 8399	·812 120	·875 5348	26
35	0·479 3940	0·546 2559	1·830 644	0·877 5998	0·483 2187	0·551 9348	1·811 808	0·875 4997	25
36	·479 4579	·546 3503	·830 327	·877 5649	·483 2824	·552 0297	·811 497	·875 4645	24
37	·479 5217	·546 4447	·830 011	·877 5300	·483 3460	·552 1245	·811 186	·875 4294	23
38	·479 5855	·546 5392	·829 695	·877 4952	·483 4097	·552 2194	·810 874	·875 3942	22
39	·479 6493	·546 6336	·829 379	·877 4603	·483 4734	·552 3143	·810 563	·875 3591	21
40	0·479 7131	0·546 7281	1·829 063	0·877 4254	0·483 5370	0·552 4093	1·810 252	0·875 3239	20
41	·479 7769	·546 8226	·828 747	·877 3905	·483 6007	·552 5042	·809 941	·875 2887	19
42	·479 8407	·546 9170	·828 431	·877 3556	·483 6643	·552 5991	·809 630	·875 2536	18
43	·479 9045	·547 0115	·828 115	·877 3207	·483 7280	·552 6940	·809 319	·875 2184	17
44	·479 9683	·547 1060	·827 799	·877 2858	·483 7916	·552 7890	·809 009	·875 1832	16
45	0·480 0321	0·547 2005	1·827 484	0·877 2509	0·483 8553	0·552 8839	1·808 698	0·875 1480	15
46	·480 0959	·547 2950	·827 168	·877 2160	·483 9189	·552 9789	·808 387	·875 1128	14
47	·480 1597	·547 3895	·826 853	·877 1811	·483 9825	·553 0738	·808 077	·875 0776	13
48	·480 2235	·547 4840	·826 537	·877 1462	·484 0462	·553 1688	·807 766	·875 0425	12
49	·480 2873	·547 5785	·826 222	·877 1112	·484 1098	·553 2638	·807 456	·875 0072	11
50	0·480 3511	0·547 6731	1·825 907	0·877 0763	0·484 1735	0·553 3588	1·807 146	0·874 9720	10
51	·480 4148	·547 7676	·825 592	·877 0414	·484 2371	·553 4538	·806 836	·874 9368	09
52	·480 4786	·547 8621	·825 277	·877 0064	·484 3007	·553 5488	·806 526	·874 9016	08
53	·480 5424	·547 9567	·824 962	·876 9715	·484 3643	·553 6438	·806 216	·874 8664	07
54	·480 6062	·548 0513	·824 647	·876 9365	·484 4279	·553 7388	·805 906	·874 8312	06
55	0·480 6700	0·548 1458	1·824 332	0·876 9016	0·484 4916	0·553 8338	1·805 596	0·874 7959	05
56	·480 7337	·548 2404	·824 017	·876 8666	·484 5552	·553 9288	·805 286	·874 7607	04
57	·480 7975	·548 3350	·823 703	·876 8317	·484 6188	·554 0239	·804 976	·874 7255	03
58	·480 8612	·548 4296	·823 388	·876 7967	·484 6824	·554 1189	·804 667	·874 6902	02
59	·480 9250	·548 5242	·823 074	·876 7617	·484 7460	·554 2140	·804 357	·874 6550	01
60	0·480 9888	0·548 6188	1·822 759	0·876 7268	0·484 8096	0·554 3091	1·804 048	0·874 6197	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	637–639	946–941	314–320	350–347	636–638	951–946	309–314	353–350	d

4h 05m **4h 04m**

$1^h\ 56^m$ $1^h\ 57^m$

d	636–634	950–955	310–304	352–356	635–633	955–960	305–300	355–358	d
	sin	tan	cot	cos	sin	tan	cot	cos	
s									
00	0·484 8096	0·554 3091	1·804 048	0·874 6197	0·488 6212	0·560 0269	1·785 628	0·872 4960	60
01	·484 8732	·554 4041	·803 738	·874 5844	·488 6847	·560 1224	·785 324	·872 4605	59
02	·484 9368	·554 4992	·803 429	·874 5492	·488 7481	·560 2180	·785 019	·872 4249	58
03	·485 0004	·554 5943	·803 120	·874 5139	·488 8116	·560 3135	·784 715	·872 3894	57
04	·485 0640	·554 6894	·802 811	·874 4786	·488 8750	·560 4091	·784 411	·872 3538	56
05	0·485 1276	0·554 7845	1·802 502	0·874 4434	0·488 9385	0·560 5047	1·784 107	0·872 3183	55
06	·485 1912	·554 8796	·802 193	·874 4081	·489 0019	·560 6002	·783 802	·872 2827	54
07	·485 2548	·554 9747	·801 884	·874 3728	·489 0653	·560 6958	·783 498	·872 2472	53
08	·485 3184	·555 0698	·801 575	·874 3375	·489 1288	·560 7914	·783 194	·872 2116	52
09	·485 3820	·555 1650	·801 266	·874 3022	·489 1922	·560 8870	·782 890	·872 1760	51
10	0·485 4455	0·555 2601	1·800 958	0·874 2669	0·489 2556	0·560 9826	1·782 586	0·872 1404	50
11	·485 5091	·555 3552	·800 649	·874 2316	·489 3190	·561 0782	·782 283	·872 1049	49
12	·485 5727	·555 4504	·800 341	·874 1963	·489 3825	·561 1738	·781 979	·872 0693	48
13	·485 6363	·555 5456	·800 032	·874 1610	·489 4459	·561 2695	·781 675	·872 0337	47
14	·485 6998	·555 6407	·799 724	·874 1257	·489 5093	·561 3651	·781 372	·871 9981	46
15	0·485 7634	0·555 7359	1·799 416	0·874 0903	0·489 5727	0·561 4607	1·781 068	0·871 9625	45
16	·485 8270	·555 8311	·799 108	·874 0550	·489 6361	·561 5564	·780 765	·871 9269	44
17	·485 8905	·555 9263	·798 800	·874 0197	·489 6995	·561 6520	·780 462	·871 8913	43
18	·485 9541	·556 0215	·798 492	·873 9843	·489 7629	·561 7477	·780 159	·871 8557	42
19	·486 0176	·556 1167	·798 184	·873 9490	·489 8263	·561 8434	·779 855	·871 8200	41
20	0·486 0812	0·556 2119	1·797 876	0·873 9137	0·489 8897	0·561 9391	1·779 552	0·871 7844	40
21	·486 1447	·556 3071	·797 568	·873 8783	·489 9531	·562 0348	·779 249	·871 7488	39
22	·486 2083	·556 4024	·797 260	·873 8429	·490 0165	·562 1305	·778 946	·871 7132	38
23	·486 2718	·556 4976	·796 953	·873 8076	·490 0799	·562 2262	·778 644	·871 6775	37
24	·486 3354	·556 5929	·796 645	·873 7722	·490 1433	·562 3219	·778 341	·871 6419	36
25	0·486 3989	0·556 6881	1·796 338	0·873 7369	0·490 2067	0·562 4176	1·778 038	0·871 6062	35
26	·486 4625	·556 7834	·796 031	·873 7015	·490 2701	·562 5133	·777 736	·871 5706	34
27	·486 5260	·556 8786	·795 723	·873 6661	·490 3334	·562 6091	·777 433	·871 5349	33
28	·486 5895	·556 9739	·795 416	·873 6307	·490 3968	·562 7048	·777 131	·871 4993	32
29	·486 6531	·557 0692	·795 109	·873 5953	·490 4602	·562 8006	·776 828	·871 4636	31
30	0·486 7166	0·557 1645	1·794 802	0·873 5599	0·490 5236	0·562 8963	1·776 526	0·871 4279	30
31	·486 7801	·557 2598	·794 495	·873 5245	·490 5869	·562 9921	·776 224	·871 3923	29
32	·486 8436	·557 3551	·794 188	·873 4891	·490 6503	·563 0879	·775 922	·871 3566	28
33	·486 9072	·557 4504	·793 881	·873 4537	·490 7137	·563 1836	·775 620	·871 3209	27
34	·486 9707	·557 5458	·793 575	·873 4183	·490 7770	·563 2794	·775 318	·871 2852	26
35	0·487 0342	0·557 6411	1·793 268	0·873 3829	0·490 8404	0·563 3752	1·775 016	0·871 2495	25
36	·487 0977	·557 7364	·792 962	·873 3475	·490 9038	·563 4710	·774 714	·871 2138	24
37	·487 1612	·557 8318	·792 655	·873 3121	·490 9671	·563 5669	·774 412	·871 1781	23
38	·487 2247	·557 9271	·792 349	·873 2766	·491 0305	·563 6627	·774 111	·871 1424	22
39	·487 2882	·558 0225	·792 042	·873 2412	·491 0938	·563 7585	·773 809	·871 1067	21
40	0·487 3517	0·558 1179	1·791 736	0·873 2058	0·491 1572	0·563 8543	1·773 508	0·871 0710	20
41	·487 4152	·558 2132	·791 430	·873 1703	·491 2205	·563 9502	·773 206	·871 0353	19
42	·487 4787	·558 3086	·791 124	·873 1349	·491 2838	·564 0461	·772 905	·870 9995	18
43	·487 5422	·558 4040	·790 818	·873 0994	·491 3472	·564 1419	·772 604	·870 9638	17
44	·487 6057	·558 4994	·790 512	·873 0640	·491 4105	·564 2378	·772 302	·870 9281	16
45	0·487 6692	0·558 5948	1·790 206	0·873 0285	0·491 4739	0·564 3337	1·772 001	0·870 8923	15
46	·487 7327	·558 6903	·789 901	·872 9930	·491 5372	·564 4295	·771 700	·870 8566	14
47	·487 7962	·558 7857	·789 595	·872 9576	·491 6005	·564 5254	·771 399	·870 8208	13
48	·487 8597	·558 8811	·789 289	·872 9221	·491 6638	·564 6213	·771 098	·870 7851	12
49	·487 9231	·558 9766	·788 984	·872 8866	·491 7272	·564 7173	·770 798	·870 7493	11
50	0·487 9866	0·559 0720	1·788 678	0·872 8511	0·491 7905	0·564 8132	1·770 497	0·870 7136	10
51	·488 0501	·559 1675	·788 373	·872 8156	·491 8538	·564 9091	·770 196	·870 6778	09
52	·488 1136	·559 2629	·788 068	·872 7801	·491 9171	·565 0050	·769 896	·870 6420	08
53	·488 1770	·559 3584	·787 763	·872 7446	·491 9804	·565 1010	·769 595	·870 6063	07
54	·488 2405	·559 4539	·787 457	·872 7091	·492 0437	·565 1969	·769 295	·870 5705	06
55	0·488 3040	0·559 5494	1·787 152	0·872 6736	0·492 1071	0·565 2929	1·768 995	0·870 5347	05
56	·488 3674	·559 6449	·786 847	·872 6381	·492 1704	·565 3888	·768 694	·870 4989	04
57	·488 4309	·559 7404	·786 543	·872 6026	·492 2337	·565 4848	·768 394	·870 4631	03
58	·488 4943	·559 8359	·786 238	·872 5671	·492 2970	·565 5808	·768 094	·870 4273	02
59	·488 5578	·559 9314	·785 933	·872 5315	·492 3603	·565 6768	·767 794	·870 3915	01
60	0·488 6212	0·560 0269	1·785 628	0·872 4960	0·492 4236	0·565 7728	1·767 494	0·870 3557	00
									s
	cos	cot	tan	sin	cos	cot	tan	sin	
d	634–636	955–950	304–310	356–352	633–635	960–955	300–305	358–355	d

$4^h\ 03^m$ $4^h\ 02^m$

$1^{h}\ 58^{m}$ $1^{h}\ 59^{m}$

d	633–631	960–965	300–295	358–361	632–629	965–970	296–291	361–364	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·492 4236	0·565 7728	1·767 494	0·870 3557	0·496 2165	0·571 5471	1·749 637	0·868 1988	60
01	·492 4869	·565 8688	·767 194	·870 3199	·496 2796	·571 6436	·749 342	·868 1627	59
02	·492 5501	·565 9648	·766 894	·870 2841	·496 3428	·571 7401	·749 047	·868 1266	58
03	·492 6134	·566 0608	·766 595	·870 2482	·496 4059	·571 8366	·748 751	·868 0905	57
04	·492 6767	·566 1568	·766 295	·870 2124	·496 4690	·571 9331	·748 456	·868 0544	56
05	0·492 7400	0·566 2529	1·765 995	0·870 1766	0·496 5322	0·572 0296	1·748 161	0·868 0183	55
06	·492 8033	·566 3489	·765 696	·870 1408	·496 5953	·572 1261	·747 866	·867 9822	54
07	·492 8666	·566 4450	·765 397	·870 1049	·496 6584	·572 2226	·747 572	·867 9461	53
08	·492 9298	·566 5410	·765 097	·870 0691	·496 7215	·572 3192	·747 277	·867 9100	52
09	·492 9931	·566 6371	·764 798	·870 0332	·496 7846	·572 4157	·746 982	·867 8739	51
10	0·493 0564	0·566 7332	1·764 499	0·869 9974	0·496 8477	0·572 5123	1·746 687	0·867 8377	50
11	·493 1196	·566 8293	·764 200	·869 9615	·496 9109	·572 6088	·746 393	·867 8016	49
12	·493 1829	·566 9254	·763 901	·869 9256	·496 9740	·572 7054	·746 098	·867 7655	48
13	·493 2462	·567 0215	·763 602	·869 8898	·497 0371	·572 8020	·745 804	·867 7293	47
14	·493 3094	·567 1176	·763 303	·869 8539	·497 1002	·572 8986	·745 510	·867 6932	46
15	0·493 3727	0·567 2137	1·763 004	0·869 8180	0·497 1633	0·572 9952	1·745 215	0·867 6570	45
16	·493 4359	·567 3098	·762 705	·869 7821	·497 2264	·573 0918	·744 921	·867 6209	44
17	·493 4992	·567 4059	·762 407	·869 7463	·497 2895	·573 1884	·744 627	·867 5847	43
18	·493 5624	·567 5021	·762 108	·869 7104	·497 3525	·573 2850	·744 333	·867 5485	42
19	·493 6257	·567 5982	·761 810	·869 6745	·497 4156	·573 3816	·744 039	·867 5124	41
20	0·493 6889	0·567 6944	1·761 511	0·869 6386	0·497 4787	0·573 4783	1·743 745	0·867 4762	40
21	·493 7522	·567 7905	·761 213	·869 6027	·497 5418	·573 5749	·743 451	·867 4400	39
22	·493 8154	·567 8867	·760 915	·869 5668	·497 6049	·573 6715	·743 158	·867 4038	38
23	·493 8786	·567 9829	·760 616	·869 5308	·497 6680	·573 7682	·742 864	·867 3676	37
24	·493 9419	·568 0791	·760 318	·869 4949	·497 7310	·573 8649	·742 571	·867 3314	36
25	0·494 0051	0·568 1753	1·760 020	0·869 4590	0·497 7941	0·573 9615	1·742 277	0·867 2952	35
26	·494 0683	·568 2715	·759 722	·869 4231	·497 8572	·574 0582	·741 984	·867 2590	34
27	·494 1315	·568 3677	·759 424	·869 3871	·497 9203	·574 1549	·741 690	·867 2228	33
28	·494 1948	·568 4639	·759 127	·869 3512	·497 9833	·574 2516	·741 397	·867 1866	32
29	·494 2580	·568 5601	·758 829	·869 3153	·498 0464	·574 3483	·741 104	·867 1504	31
30	0·494 3212	0·568 6564	1·758 531	0·869 2793	0·498 1094	0·574 4450	1·740 811	0·867 1142	30
31	·494 3844	·568 7526	·758 234	·869 2434	·498 1725	·574 5418	·740 518	·867 0779	29
32	·494 4476	·568 8488	·757 936	·869 2074	·498 2355	·574 6385	·740 225	·867 0417	28
33	·494 5108	·568 9451	·757 639	·869 1715	·498 2986	·574 7352	·739 932	·867 0055	27
34	·494 5741	·569 0414	·757 341	·869 1355	·498 3616	·574 8320	·739 639	·866 9692	26
35	0·494 6373	0·569 1376	1·757 044	0·869 0995	0·498 4247	0·574 9287	1·739 346	0·866 9330	25
36	·494 7005	·569 2339	·756 747	·869 0636	·498 4877	·575 0255	·739 053	·866 8967	24
37	·494 7637	·569 3302	·756 450	·869 0276	·498 5508	·575 1223	·738 761	·866 8605	23
38	·494 8269	·569 4265	·756 153	·868 9916	·498 6138	·575 2191	·738 468	·866 8242	22
39	·494 8900	·569 5228	·755 856	·868 9556	·498 6769	·575 3158	·738 176	·866 7880	21
40	0·494 9532	0·569 6191	1·755 559	0·868 9196	0·498 7399	0·575 4126	1·737 883	0·866 7517	20
41	·495 0164	·569 7155	·755 262	·868 8836	·498 8029	·575 5094	·737 591	·866 7154	19
42	·495 0796	·569 8118	·754 965	·868 8476	·498 8659	·575 6063	·737 299	·866 6792	18
43	·495 1428	·569 9081	·754 669	·868 8116	·498 9290	·575 7031	·737 007	·866 6429	17
44	·495 2060	·570 0045	·754 372	·868 7756	·498 9920	·575 7999	·736 714	·866 6066	16
45	0·495 2692	0·570 1008	1·754 076	0·868 7396	0·499 0550	0·575 8967	1·736 422	0·866 5703	15
46	·495 3323	·570 1972	·753 779	·868 7036	·499 1180	·575 9936	·736 130	·866 5340	14
47	·495 3955	·570 2936	·753 483	·868 6675	·499 1810	·576 0904	·735 839	·866 4977	13
48	·495 4587	·570 3899	·753 187	·868 6315	·499 2441	·576 1873	·735 547	·866 4614	12
49	·495 5218	·570 4863	·752 890	·868 5955	·499 3071	·576 2842	·735 255	·866 4251	11
50	0·495 5850	0·570 5827	1·752 594	0·868 5594	0·499 3701	0·576 3810	1·734 963	0·866 3888	10
51	·495 6482	·570 6791	·752 298	·868 5234	·499 4331	·576 4779	·734 672	·866 3525	09
52	·495 7113	·570 7755	·752 002	·868 4874	·499 4961	·576 5748	·734 380	·866 3161	08
53	·495 7745	·570 8719	·751 706	·868 4513	·499 5591	·576 6717	·734 089	·866 2798	07
54	·495 8376	·570 9684	·751 411	·868 4152	·499 6221	·576 7686	·733 797	·866 2435	06
55	0·495 9008	0·571 0648	1·751 115	0·868 3792	0·499 6851	0·576 8656	1·733 506	0·866 2072	05
56	·495 9639	·571 1612	·750 819	·868 3431	·499 7481	·576 9625	·733 215	·866 1708	04
57	·496 0271	·571 2577	·750 523	·868 3071	·499 8111	·577 0594	·732 924	·866 1345	03
58	·496 0902	·571 3541	·750 228	·868 2710	·499 8740	·577 1564	·732 633	·866 0981	02
59	·496 1534	·571 4506	·749 932	·868 2349	·499 9370	·577 2533	·732 342	·866 0618	01
60	0·496 2165	0·571 5471	1·749 637	0·868 1988	0·500 0000	0·577 3503	1·732 051	0·866 0254	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	631–633	965–960	295–300	361–358	629–632	970–965	291–296	364–361	d

$4^{h}\ 01^{m}$ $4^{h}\ 00^{m}$

$2^{h}\ 00^{m}$ $2^{h}\ 01^{m}$

d	630–628	969–975	2908–2866	363–367	629–626	974–980	2865–2824	366–369	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·500 0000	0·577 3503	1·732 0508	0·866 0254	0·503 7740	0·583 1828	1·714 7283	0·863 8355	60
01	·500 0630	·577 4472	·731 7600	·865 9890	·503 8368	·583 2802	·714 4418	·863 7989	59
02	·500 1260	·577 5442	·731 4692	·865 9527	·503 8996	·583 3777	·714 1554	·863 7622	58
03	·500 1889	·577 6412	·731 1785	·865 9163	·503 9624	·583 4752	·713 8690	·863 7256	57
04	·500 2519	·577 7382	·730 8878	·865 8799	·504 0252	·583 5726	·713 5827	·863 6889	56
05	0·500 3149	0·577 8352	1·730 5973	0·865 8435	0·504 0880	0·583 6701	1·713 2965	0·863 6523	55
06	·500 3778	·577 9322	·730 3068	·865 8072	·504 1508	·583 7676	·713 0103	·863 6156	54
07	·500 4408	·578 0292	·730 0164	·865 7708	·504 2137	·583 8652	·712 7242	·863 5789	53
08	·500 5037	·578 1262	·729 7260	·865 7344	·504 2765	·583 9627	·712 4382	·863 5423	52
09	·500 5667	·578 2233	·729 4358	·865 6980	·504 3392	·584 0602	·712 1523	·863 5056	51
10	0·500 6297	0·578 3203	1·729 1456	0·865 6616	0·504 4020	0·584 1577	1·711 8664	0·863 4689	50
11	·500 6926	·578 4174	·728 8555	·865 6252	·504 4648	·584 2553	·711 5806	·863 4322	49
12	·500 7556	·578 5144	·728 5654	·865 5887	·504 5276	·584 3528	·711 2949	·863 3956	48
13	·500 8185	·578 6115	·728 2754	·865 5523	·504 5904	·584 4504	·711 0092	·863 3589	47
14	·500 8814	·578 7085	·727 9855	·865 5159	·504 6532	·584 5479	·710 7237	·863 3222	46
15	0·500 9444	0·578 8056	1·727 6957	0·865 4795	0·504 7160	0·584 6455	1·710 4381	0·863 2855	45
16	·501 0073	·578 9027	·727 4060	·865 4430	·504 7788	·584 7431	·710 1527	·863 2488	44
17	·501 0703	·578 9998	·727 1163	·865 4066	·504 8415	·584 8407	·709 8673	·863 2120	43
18	·501 1332	·579 0969	·726 8267	·865 3702	·504 9043	·584 9383	·709 5820	·863 1753	42
19	·501 1961	·579 1940	·726 5371	·865 3337	·504 9671	·585 0359	·709 2968	·863 1386	41
20	0·501 2591	0·579 2912	1·726 2477	0·865 2973	0·505 0298	0·585 1335	1·709 0116	0·863 1019	40
21	·501 3220	·579 3883	·725 9583	·865 2608	·505 0926	·585 2311	·708 7266	·863 0652	39
22	·501 3849	·579 4854	·725 6689	·865 2244	·505 1554	·585 3288	·708 4415	·863 0284	38
23	·501 4478	·579 5826	·725 3797	·865 1879	·505 2181	·585 4264	·708 1566	·862 9917	37
24	·501 5107	·579 6797	·725 0905	·865 1514	·505 2809	·585 5241	·707 8717	·862 9549	36
25	0·501 5737	0·579 7769	1·724 8014	0·865 1149	0·505 3436	0·585 6217	1·707 5869	0·862 9182	35
26	·501 6366	·579 8741	·724 5124	·865 0785	·505 4064	·585 7194	·707 3022	·862 8814	34
27	·501 6995	·579 9712	·724 2234	·865 0420	·505 4691	·585 8171	·707 0175	·862 8447	33
28	·501 7624	·580 0684	·723 9346	·865 0055	·505 5319	·585 9148	·706 7329	·862 8079	32
29	·501 8253	·580 1656	·723 6457	·864 9690	·505 5946	·586 0124	·706 4484	·862 7712	31
30	0·501 8882	0·580 2628	1·723 3570	0·864 9325	0·505 6574	0·586 1101	1·706 1640	0·862 7344	30
31	·501 9511	·580 3600	·723 0683	·864 8960	·505 7201	·586 2078	·705 8796	·862 6976	29
32	·502 0140	·580 4573	·722 7797	·864 8595	·505 7828	·586 3056	·705 5953	·862 6608	28
33	·502 0769	·580 5545	·722 4912	·864 8230	·505 8456	·586 4033	·705 3110	·862 6240	27
34	·502 1398	·580 6517	·722 2028	·864 7865	·505 9083	·586 5010	·705 0269	·862 5873	26
35	0·502 2026	0·580 7490	1·721 9144	0·864 7500	0·505 9710	0·586 5988	1·704 7428	0·862 5505	25
36	·502 2655	·580 8462	·721 6261	·864 7134	·506 0338	·586 6965	·704 4587	·862 5137	24
37	·502 3284	·580 9435	·721 3378	·864 6769	·506 0965	·586 7943	·704 1748	·862 4769	23
38	·502 3913	·581 0408	·721 0497	·864 6404	·506 1592	·586 8920	·703 8909	·862 4401	22
39	·502 4542	·581 1380	·720 7616	·864 6038	·506 2219	·586 9898	·703 6071	·862 4032	21
40	0·502 5170	0·581 2353	1·720 4736	0·864 5673	0·506 2846	0·587 0876	1·703 3233	0·862 3664	20
41	·502 5799	·581 3326	·720 1856	·864 5308	·506 3473	·587 1854	·703 0397	·862 3296	19
42	·502 6428	·581 4299	·719 8978	·864 4942	·506 4101	·587 2832	·702 7560	·862 2928	18
43	·502 7057	·581 5272	·719 6100	·864 4576	·506 4728	·587 3810	·702 4725	·862 2560	17
44	·502 7685	·581 6245	·719 3222	·864 4211	·506 5355	·587 4788	·702 1890	·862 2191	16
45	0·502 8314	0·581 7219	1·719 0346	0·864 3845	0·506 5982	0·587 5766	1·701 9056	0·862 1823	15
46	·502 8942	·581 8192	·718 7470	·864 3480	·506 6609	·587 6745	·701 6223	·862 1454	14
47	·502 9571	·581 9165	·718 4595	·864 3114	·506 7236	·587 7723	·701 3391	·862 1086	13
48	·503 0199	·582 0139	·718 1720	·864 2748	·506 7863	·587 8702	·701 0559	·862 0717	12
49	·503 0828	·582 1113	·717 8847	·864 2382	·506 8489	·587 9680	·700 7728	·862 0349	11
50	0·503 1456	0·582 2086	1·717 5974	0·864 2016	0·506 9116	0·588 0659	1·700 4897	0·861 9980	10
51	·503 2085	·582 3060	·717 3101	·864 1650	·506 9743	·588 1638	·700 2067	·861 9612	09
52	·503 2713	·582 4034	·717 0230	·864 1284	·507 0370	·588 2616	·699 9238	·861 9243	08
53	·503 3342	·582 5008	·716 7359	·864 0918	·507 0997	·588 3595	·699 6410	·861 8874	07
54	·503 3970	·582 5982	·716 4489	·864 0552	·507 1624	·588 4574	·699 3582	·861 8505	06
55	0·503 4598	0·582 6956	1·716 1619	0·864 0186	0·507 2250	0·588 5553	1·699 0755	0·861 8136	05
56	·503 5227	·582 7930	·715 8751	·863 9820	·507 2877	·588 6533	·698 7929	·861 7768	04
57	·503 5855	·582 8904	·715 5883	·863 9454	·507 3504	·588 7512	·698 5104	·861 7399	03
58	·503 6483	·582 9879	·715 3016	·863 9088	·507 4130	·588 8491	·698 2279	·861 7030	02
59	·503 7112	·583 0853	·715 0149	·863 8721	·507 4757	·588 9471	·697 9455	·861 6661	01
60	0·503 7740	0·583 1828	1·714 7283	0·863 8355	0·507 5384	0·589 0450	1·697 6631	0·861 6292	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	628–630	975–969	2866–2908	367–363	626–629	980–974	2824–2865	369–366	d

$3^{h}\ 59^{m}$ $3^{h}\ 58^{m}$

2^h 02^m **2^h 03^m**

d	627–625	979–985	2823–2782	369–372	625–623	984–990	2782–2742	372–375	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·507 5384	0·589 0450	1·697 6631	0·861 6292	0·511 2931	0·594 9375	1·680 8489	0·859 4064	60
01	·507 6010	·589 1430	·697 3808	·861 5922	·511 3556	·595 0359	·680 5707	·859 3692	59
02	·507 6637	·589 2409	·697 0986	·861 5553	·511 4181	·595 1344	·680 2927	·859 3320	58
03	·507 7263	·589 3389	·696 8165	·861 5184	·511 4806	·595 2329	·680 0146	·859 2948	57
04	·507 7890	·589 4369	·696 5344	·861 4815	·511 5431	·595 3314	·679 7367	·859 2576	56
05	0·507 8516	0·589 5349	1·696 2524	0·861 4446	0·511 6055	0·595 4299	1·679 4588	0·859 2204	55
06	·507 9143	·589 6329	·695 9705	·861 4076	·511 6680	·595 5284	·679 1810	·859 1832	54
07	·507 9769	·589 7309	·695 6886	·861 3707	·511 7305	·595 6269	·678 9033	·859 1460	53
08	·508 0396	·589 8289	·695 4069	·861 3337	·511 7930	·595 7255	·678 6256	·859 1088	52
09	·508 1022	·589 9269	·695 1251	·861 2968	·511 8555	·595 8240	·678 3480	·859 0716	51
10	0·508 1648	0·590 0250	1·694 8435	0·861 2598	0·511 9179	0·595 9225	1·678 0705	0·859 0344	50
11	·508 2275	·590 1230	·694 5619	·861 2229	·511 9804	·596 0211	·677 7930	·858 9971	49
12	·508 2901	·590 2211	·694 2804	·861 1859	·512 0429	·596 1196	·677 5156	·858 9599	48
13	·508 3527	·590 3191	·693 9990	·861 1490	·512 1053	·596 2182	·677 2383	·858 9227	47
14	·508 4153	·590 4172	·693 7176	·861 1120	·512 1678	·596 3168	·676 9610	·858 8854	46
15	0·508 4780	0·590 5153	1·693 4363	0·861 0750	0·512 2302	0·596 4154	1·676 6838	0·858 8482	45
16	·508 5406	·590 6134	·693 1550	·861 0380	·512 2927	·596 5140	·676 4067	·858 8109	44
17	·508 6032	·590 7115	·692 8739	·861 0010	·512 3552	·596 6126	·676 1296	·858 7737	43
18	·508 6658	·590 8096	·692 5928	·860 9641	·512 4176	·596 7112	·675 8526	·858 7364	42
19	·508 7284	·590 9077	·692 3118	·860 9271	·512 4801	·596 8098	·675 5757	·858 6991	41
20	0·508 7910	0·591 0058	1·692 0308	0·860 8901	0·512 5425	0·596 9084	1·675 2988	0·858 6619	40
21	·508 8536	·591 1039	·691 7499	·860 8531	·512 6049	·597 0071	·675 0220	·858 6246	39
22	·508 9162	·591 2021	·691 4691	·860 8161	·512 6674	·597 1057	·674 7453	·858 5873	38
23	·508 9788	·591 3002	·691 1883	·860 7790	·512 7298	·597 2044	·674 4687	·858 5500	37
24	·509 0414	·591 3984	·690 9077	·860 7420	·512 7923	·597 3030	·674 1921	·858 5127	36
25	0·509 1040	0·591 4965	1·690 6270	0·860 7050	0·512 8547	0·597 4017	1·673 9156	0·858 4754	35
26	·509 1666	·591 5947	·690 3465	·860 6680	·512 9171	·597 5004	·673 6391	·858 4381	34
27	·509 2292	·591 6929	·690 0660	·860 6310	·512 9795	·597 5991	·673 3627	·858 4008	33
28	·509 2918	·591 7910	·689 7856	·860 5939	·513 0420	·597 6978	·673 0864	·858 3635	32
29	·509 3544	·591 8892	·689 5053	·860 5569	·513 1044	·597 7965	·672 8101	·858 3262	31
30	0·509 4169	0·591 9874	1·689 2250	0·860 5198	0·513 1668	0·597 8952	1·672 5340	0·858 2889	30
31	·509 4795	·592 0857	·688 9448	·860 4828	·513 2292	·597 9939	·672 2578	·858 2516	29
32	·509 5421	·592 1839	·688 6647	·860 4457	·513 2916	·598 0926	·671 9818	·858 2143	28
33	·509 6047	·592 2821	·688 3846	·860 4087	·513 3540	·598 1914	·671 7058	·858 1769	27
34	·509 6672	·592 3803	·688 1046	·860 3716	·513 4164	·598 2901	·671 4299	·858 1396	26
35	0·509 7298	0·592 4786	1·687 8247	0·860 3345	0·513 4789	0·598 3889	1·671 1540	0·858 1022	25
36	·509 7924	·592 5768	·687 5449	·860 2975	·513 5413	·598 4877	·670 8782	·858 0649	24
37	·509 8549	·592 6751	·687 2651	·860 2604	·513 6037	·598 5864	·670 6025	·858 0276	23
38	·509 9175	·592 7734	·686 9854	·860 2233	·513 6660	·598 6852	·670 3269	·857 9902	22
39	·509 9800	·592 8717	·686 7057	·860 1862	·513 7284	·598 7840	·670 0513	·857 9528	21
40	0·510 0426	0·592 9699	1·686 4261	0·860 1491	0·513 7908	0·598 8828	1·669 7758	0·857 9155	20
41	·510 1051	·593 0682	·686 1466	·860 1121	·513 8532	·598 9816	·669 5003	·857 8781	19
42	·510 1677	·593 1665	·685 8672	·860 0750	·513 9156	·599 0804	·669 2250	·857 8407	18
43	·510 2302	·593 2649	·685 5878	·860 0379	·513 9780	·599 1793	·668 9496	·857 8034	17
44	·510 2928	·593 3632	·685 3085	·860 0007	·514 0404	·599 2781	·668 6744	·857 7660	16
45	0·510 3553	0·593 4615	1·685 0293	0·859 9636	0·514 1027	0·599 3769	1·668 3992	0·857 7286	15
46	·510 4179	·593 5598	·684 7501	·859 9265	·514 1651	·599 4758	·668 1241	·857 6912	14
47	·510 4804	·593 6582	·684 4710	·859 8894	·514 2275	·599 5746	·667 8490	·857 6538	13
48	·510 5429	·593 7565	·684 1919	·859 8523	·514 2899	·599 6735	·667 5741	·857 6164	12
49	·510 6054	·593 8549	·683 9130	·859 8151	·514 3522	·599 7724	·667 2991	·857 5790	11
50	0·510 6680	0·593 9533	1·683 6341	0·859 7780	0·514 4146	0·599 8713	1·667 0243	0·857 5416	10
51	·510 7305	·594 0517	·683 3553	·859 7409	·514 4769	·599 9702	·666 7495	·857 5042	09
52	·510 7930	·594 1501	·683 0765	·859 7037	·514 5393	·600 0691	·666 4748	·857 4668	08
53	·510 8555	·594 2485	·682 7978	·859 6666	·514 6017	·600 1680	·666 2002	·857 4294	07
54	·510 9181	·594 3469	·682 5192	·859 6294	·514 6640	·600 2669	·665 9256	·857 3919	06
55	0·510 9806	0·594 4453	1·682 2406	0·859 5923	0·514 7264	0·600 3658	1·665 6511	0·857 3545	05
56	·511 0431	·594 5437	·681 9621	·859 5551	·514 7887	·600 4648	·665 3766	·857 3171	04
57	·511 1056	·594 6421	·681 6837	·859 5179	·514 8511	·600 5637	·665 1022	·857 2796	03
58	·511 1681	·594 7406	·681 4054	·859 4808	·514 9134	·600 6627	·664 8279	·857 2422	02
59	·511 2306	·594 8390	·681 1271	·859 4436	·514 9757	·600 7616	·664 5537	·857 2048	01
60	0·511 2931	0·594 9375	1·680 8489	0·859 4064	0·515 0381	0·600 8606	1·664 2795	0·857 1673	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	625–627	985–979	2782–2823	372–369	623–625	990–984	2742–2782	375–372	d

3^h 57^m **3^h 56^m**

2^h 04^m 2^h 05^m

d	624–621	990–995	2741–2702	374–377	622–620	995–1001	2702–2664	377–380	d
	sin	tan	cot	cos	sin	tan	cot	cos	
s									
00	0·515 0381	0·600 8606	1·664 2795	0·857 1673	0·518 7733	0·606 8149	1·647 9490	0·854 9119	60
01	·515 1004	·600 9596	·664 0054	·857 1298	·518 8354	·606 9144	·647 6788	·854 8741	59
02	·515 1627	·601 0586	·663 7313	·857 0924	·518 8976	·607 0139	·647 4087	·854 8364	58
03	·515 2251	·601 1576	·663 4573	·857 0549	518 9598	·607 1134	·647 1386	·854 7987	57
04	·515 2874	·601 2566	·663 1834	·857 0174	·519 0219	·607 2130	·646 8687	·854 7609	56
05	0·515 3497	0·601 3556	1·662 9096	0·856 9800	0·519 0841	0·607 3125	1·646 5987	0·854 7232	55
06	·515 4120	·601 4546	·662 6358	·856 9425	·519 1462	·607 4121	·646 3289	·854 6854	54
07	·515 4744	·601 5537	·662 3621	·856 9050	·519 2084	·607 5116	·646 0591	·854 6477	53
08	·515 5367	·601 6527	·662 0884	·856 8675	·519 2705	·607 6112	·645 7893	·854 6099	52
09	·515 5990	·601 7518	·661 8148	·856 8300	·519 3327	·607 7108	·645 5197	·854 5722	51
10	0·515 6613	0·601 8508	1·661 5413	0·856 7925	0·519 3948	0·607 8103	1·645 2501	0·854 5344	50
11	·515 7236	·601 9499	·661 2678	·856 7550	·519 4570	·607 9099	·644 9805	·854 4966	49
12	·515 7859	·602 04[illegible]	·660 9945	·856 7175	·519 5191	·608 0095	·644 7111	·854 4588	48
13	·515 8482	·602 1481	·660 7211	·856 6800	·519 5812	·608 1091	·644 4417	·854 4210	47
14	·515 9105	·602 2471	·660 4479	·856 6425	·519 6434	·608 2088	·644 1723	·854 3833	46
15	0·515 9728	0·602 3463	1·660 1747	0·856 6050	0·519 7055	0·608 3084	1·643 9030	0·854 3455	45
16	·516 0351	·602 4454	·659 9016	·856 5674	·519 7676	·608 4080	·643 6338	·854 3077	44
17	·516 0974	·602 5445	·659 6285	·856 5299	·519 8298	·608 5077	·643 3647	·854 2699	43
18	·516 1597	·602 6436	·659 3555	·856 4924	·519 8919	·608 6073	·643 0956	·854 2321	42
19	·516 2219	·602 7427	·659 0826	·856 4548	·519 9540	·608 7070	·642 8266	·854 1943	41
20	0·516 2842	0·602 8419	1·658 8097	0·856 4173	0·520 0161	0·608 8067	1·642 5576	0·854 1564	40
21	·516 3465	·602 9410	·658 5369	·856 3798	·520 0782	·608 9063	·642 2887	·854 1186	39
22	·516 4088	·603 0402	·658 2642	·856 3422	·520 1404	·609 0060	·642 0199	·854 0808	38
23	·516 4711	·603 1394	·657 9915	·856 3046	·520 2025	·609 1057	·641 7511	·854 0430	37
24	·516 5333	·603 2386	·657 7189	·856 2671	·520 2646	·609 2054	·641 4824	·854 0051	36
25	0·516 5956	0·603 3378	1·657 4464	0·856 2295	0·520 3267	0·609 3051	1·641 2138	0·853 9673	35
26	·516 6579	·603 4370	·657 1739	·856 1919	·520 3888	·609 4049	·640 9452	·853 9295	34
27	·516 7201	·603 5362	·656 9015	·856 1544	·520 4509	·609 5046	·640 6767	·853 8916	33
28	·516 7824	·603 6354	·656 6292	·856 1168	·520 5130	·609 6043	·640 4082	·853 8538	32
29	·516 8446	·603 7346	·656 3569	·856 0792	·520 5751	·609 7041	·640 1399	·853 8159	31
30	0·516 9069	0·603 8338	1·656 0847	0·856 0416	0·520 6372	0·609 8039	1·639 8715	0·853 7780	30
31	·516 9691	·603 9331	·655 8126	·856 0040	·520 6992	·609 9036	·639 6033	·853 7402	29
32	·517 0314	·604 0323	·655 5405	·855 9664	·520 7613	·610 0034	·639 3351	·853 7023	28
33	·517 0936	·604 1316	·655 2685	·855 9288	·520 8234	·610 1032	·639 0670	·853 6644	27
34	·517 1559	·604 2309	·654 9966	·855 8912	·520 8855	·610 2030	·638 7989	·853 6266	26
35	0·517 2181	0·604 3301	1·654 7247	0·855 8536	0·520 9476	0·610 3028	1·638 5309	0·853 5887	25
36	·517 2804	·604 4294	·654 4529	·855 8160	·521 0096	·610 4026	·638 2630	·853 5508	24
37	·517 3426	·604 5287	·654 1811	·855 7784	·521 0717	·610 5024	·637 9951	·853 5129	23
38	·517 4048	·604 6280	·653 9095	·855 7408	·521 1338	·610 6023	·637 7273	·853 4750	22
39	·517 4671	·604 7273	·653 6379	·855 7031	·521 1958	·610 7021	·637 4596	·853 4371	21
40	0·517 5293	0·604 8266	1·653 3663	0·855 6655	0·521 2579	0·610 8019	1·637 1919	0·853 3992	20
41	·517 5915	·604 9260	·653 0948	·855 6279	·521 3200	·610 9018	·636 9243	·853 3613	19
42	·517 6537	·605 0253	·652 8234	·855 5902	·521 3820	·611 0017	·636 6567	·853 3234	18
43	·517 7160	·605 1247	·652 5520	·855 5526	·521 4441	·611 1015	·636 3892	·853 2855	17
44	·517 7782	·605 2240	·652 2808	·855 5149	·521 5061	·611 2014	·636 1218	·853 2475	16
45	0·517 8404	0·605 3234	1·652 0095	0·855 4773	0·521 5682	0·611 3013	1·635 8545	0·853 2096	15
46	·517 9026	·605 4228	·651 7384	·855 4396	·521 6302	·611 4012	·635 5872	·853 1717	14
47	·517 9648	·605 5221	·651 4673	·855 4019	·521 6923	·611 5011	·635 3199	·853 1337	13
48	·518 0270	·605 6215	·651 1963	·855 3643	·521 7543	·611 6011	·635 0528	·853 0958	12
49	·518 0892	·605 7209	·650 9253	·855 3266	·521 8163	·611 7010	·634 7857	·853 0579	11
50	0·518 1514	0·605 8203	1·650 6544	0·855 2889	0·521 8784	0·611 8009	1·634 5186	0·853 0199	10
51	·518 2136	·605 9198	·650 3836	·855 2512	·521 9404	·611 9009	·634 2516	·852 9820	09
52	·518 2758	·606 0192	·650 1128	·855 2135	·522 0024	·612 0008	·633 9847	·852 9440	08
53	·518 3380	·606 1186	·649 8421	·855 1758	·522 0645	·612 1008	·633 7179	·852 9060	07
54	·518 4002	·606 2181	·649 5715	·855 1381	·522 1265	·612 2008	·633 4511	·852 8681	06
55	0·518 4624	0·606 3175	1·649 3009	0·855 1004	0·522 1885	0·612 3007	1·633 1844	0·852 8301	05
56	·518 5246	·606 4170	·649 0304	·855 0627	·522 2505	·612 4007	·632 9177	·852 7921	04
57	·518 5867	·606 5164	·648 7599	·855 0250	·522 3125	·612 5007	·632 6511	·852 7541	03
58	·518 6489	·606 6159	·648 4896	·854 9873	·522 3745	·612 6007	·632 3846	·852 7161	02
59	·518 7111	·606 7154	·648 2192	·854 9496	·522 4366	·612 7008	·632 1181	·852 6782	01
60	0·518 7733	0·606 8149	1·647 9490	0·854 9119	0·522 4986	0·612 8008	1·631 8517	0·852 6402	00
′									s
	cos	cot	tan	sin	cos	cot	tan	sin	
d	621–624	995–990	2702–2741	377–374	620–622	1001–995	2664–2702	380–377	d

3^h 55^m 3^h 54^m

$2^{h}\ 06^{m}$ $2^{h}\ 07^{m}$

d	620–618	1000–1006	2664–2627	380–383	619–616	1005–1012	2626–2590	382–386	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·522 4986	0·612 8008	1·631 8517	0·852 6402	0·526 2139	0·618 8188	1·615 9820	0·850 3522	60
01	·522 5606	·612 9008	·631 5853	·852 6022	·526 2758	·618 9194	·615 7194	·850 3140	59
02	·522 6226	·613 0009	·631 3191	·852 5642	·526 3376	·619 0199	·615 4569	·850 2757	58
03	·522 6846	·613 1009	·631 0528	·852 5262	·526 3994	·619 1205	·615 1944	·850 2374	57
04	·522 7466	·613 2010	·630 7867	·852 4881	·526 4613	·619 2211	·614 9320	·850 1991	56
05	0·522 8086	0·613 3011	1·630 5206	0·852 4501	0·526 5231	0·619 3217	1·614 6696	0·850 1608	55
06	·522 8705	·613 4011	·630 2546	·852 4121	·526 5849	·619 4224	·614 4073	·850 1225	54
07	·522 9325	·613 5012	·629 9886	·852 3741	·526 6467	·619 5230	·614 1451	·850 0842	53
08	·522 9945	·613 6013	·629 7227	·852 3360	·526 7085	·619 6236	·613 8829	·850 0459	52
09	·523 0565	·613 7014	·629 4569	·852 2980	·526 7704	·619 7243	·613 6208	·850 0076	51
10	0·523 1185	0·613 8015	1·629 1911	0·852 2600	0·526 8322	0·619 8249	1·613 3588	0·849 9693	50
11	·523 1805	·613 9017	·628 9254	·852 2219	·526 8940	·619 9256	·613 0968	·849 9310	49
12	·523 2424	·614 0018	·628 6597	·852 1839	·526 9558	·620 0263	·612 8349	·849 8927	48
13	·523 3044	·614 1019	·628 3941	·852 1458	·527 0176	·620 1270	·612 5730	·849 8544	47
14	·523 3664	·614 2021	·628 1286	·852 1078	·527 0794	·620 2276	·612 3112	·849 8160	46
15	0·523 4283	0·614 3023	1·627 8631	0·852 0697	0·527 1412	0·620 3283	1·612 0495	0·849 7777	45
16	·523 4903	·614 4024	·627 5977	·852 0316	·527 2030	·620 4291	·611 7878	·849 7394	44
17	·523 5523	·614 5026	·627 3324	·851 9936	·527 2648	·620 5298	·611 5262	·849 7010	43
18	·523 6142	·614 6028	·627 0671	·851 9555	·527 3266	·620 6305	·611 2647	·849 6627	42
19	·523 6762	·614 7030	·626 8019	·851 9174	·527 3884	·620 7312	·611 0032	·849 6243	41
20	0·523 7381	0·614 8032	1·626 5368	0·851 8793	0·527 4502	0·620 8320	1·610 7417	0·849 5860	40
21	·523 8001	·614 9034	·626 2717	·851 8412	·527 5119	·620 9327	·610 4804	·849 5476	39
22	·523 8620	·615 0036	·626 0067	·851 8031	·527 5737	·621 0335	·610 2191	·849 5093	38
23	·523 9240	·615 1039	·625 7417	·851 7650	·527 6355	·621 1343	·609 9578	·849 4709	37
24	·523 9859	·615 2041	·625 4768	·851 7269	·527 6973	·621 2351	·609 6966	·849 4325	36
25	0·524 0478	0·615 3044	1·625 2120	0·851 6888	0·527 7590	0·621 3359	1·609 4355	0·849 3941	35
26	·524 1098	·615 4046	·624 9472	·851 6507	·527 8208	·621 4367	·609 1745	·849 3558	34
27	·524 1717	·615 5049	·624 6825	·851 6126	·527 8826	·621 5375	·608 9134	·849 3174	33
28	·524 2336	·615 6052	·624 4178	·851 5745	·527 9443	·621 6383	·608 6525	·849 2790	32
29	·524 2956	·615 7054	·624 1533	·851 5364	·528 0061	·621 7391	·608 3916	·849 2406	31
30	0·524 3575	0·615 8057	1·623 8887	0·851 4982	0·528 0679	0·621 8400	1·608 1308	0·849 2022	30
31	·524 4194	·615 9060	·623 6243	·851 4601	·528 1296	·621 9408	·607 8701	·849 1638	29
32	·524 4813	·616 0064	·623 3599	·851 4219	·528 1914	·622 0417	·607 6094	·849 1254	28
33	·524 5432	·616 1067	·623 0955	·851 3838	·528 2531	·622 1425	·607 3487	·849 0870	27
34	·524 6052	·616 2070	·622 8313	·851 3457	·528 3149	·622 2434	·607 0882	·849 0485	26
35	0·524 6671	0·616 3073	1·622 5671	0·851 3075	0·528 3766	0·622 3443	1·606 8276	0·849 0101	25
36	·524 7290	·616 4077	·622 3029	·851 2693	·528 4383	·622 4452	·606 5672	·848 9717	24
37	·524 7909	·616 5081	·622 0388	·851 2312	·528 5001	·622 5461	·606 3068	·848 9333	23
38	·524 8528	·616 6084	·621 7748	·851 1930	·528 5618	·622 6470	·606 0465	·848 8948	22
39	·524 9147	·616 7088	·621 5108	·851 1548	·528 6235	·622 7479	·605 7862	·848 8564	21
40	0·524 9766	0·616 8092	1·621 2469	0·851 1167	0·528 6853	0·622 8488	1·605 5260	0·848 8179	20
41	·525 0385	·616 9096	·620 9831	·851 0785	·528 7470	·622 9498	·605 2658	·848 7795	19
42	·525 1004	·617 0100	·620 7193	·851 0403	·528 8087	·623 0507	·605 0057	·848 7410	18
43	·525 1623	·617 1104	·620 4556	·851 0021	·528 8704	·623 1517	·604 7457	·848 7026	17
44	·525 2241	·617 2108	·620 1920	·850 9639	·528 9322	·623 2527	·604 4858	·848 6641	16
45	0·525 2860	0·617 3112	1·619 9284	0·850 9257	0·528 9939	0·623 3536	1·604 2258	0·848 6256	15
46	·525 3479	·617 4117	·619 6648	·850 8875	·529 0556	·623 4546	·603 9660	·848 5872	14
47	·525 4098	·617 5121	·619 4014	·850 8493	·529 1173	·623 5556	·603 7062	·848 5487	13
48	·525 4717	·617 6126	·619 1380	·850 8111	·529 1790	·623 6566	·603 4465	·848 5102	12
49	·525 5335	·617 7131	·618 8746	·850 7729	·529 2407	·623 7576	·603 1868	·848 4717	11
50	0·525 5954	0·617 8135	1·618 6114	0·850 7347	0·529 3024	0·623 8586	1·602 9272	0·848 4332	10
51	·525 6573	·617 9140	·618 3482	·850 6964	·529 3641	·623 9597	·602 6677	·848 3947	09
52	·525 7191	·618 0145	·618 0850	·850 6582	·529 4258	·624 0607	·602 4082	·848 3562	08
53	·525 7810	·618 1150	·617 8219	·850 6200	·529 4875	·624 1618	·602 1488	·848 3177	07
54	·525 8428	·618 2155	·617 5589	·850 5817	·529 5492	·624 2628	·601 8894	·848 2792	06
55	0·525 9047	0·618 3160	1·617 2959	0·850 5435	0·529 6109	0·624 3639	1·601 6301	0·848 2407	05
56	·525 9665	·618 4166	·617 0330	·850 5053	·529 6726	·624 4650	·601 3709	·848 2022	04
57	·526 0284	·618 5171	·616 7702	·850 4670	·529 7342	·624 5660	·601 1117	·848 1637	03
58	·526 0902	·618 6177	·616 5074	·850 4288	·529 7959	·624 6671	·600 8526	·848 1252	02
59	·526 1521	·618 7182	·616 2447	·850 3905	·529 8576	·624 7682	·600 5935	·848 0866	01
60	0·526 2139	0·618 8188	1·615 9820	0·850 3522	0·529 9193	0·624 8694	1·600 3345	0·848 0481	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	618–620	1006–1000	2627–2664	383–380	616–619	1012–1005	2590–2626	386–382	d

$3^{h}\ 53^{m}$ $3^{h}\ 52^{m}$

$2^{h}\ 08^{m}$ $2^{h}\ 09^{m}$

d	617–615	1011–1017	2589–2554	385–388	615–613	1017–1023	2554–2519	388–391	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·529 9193	0·624 8694	1·600 3345	0·848 0481	0·533 6145	0·630 9530	1·584 9041	0·845 7278	60
01	·529 9809	·624 9705	·600 0756	·848 0096	·533 6760	·631 0547	·584 6487	·845 6890	59
02	·530 0426	·625 0716	·599 8167	·847 9710	·533 7375	·631 1564	·584 3934	·845 6502	58
03	·530 1043	·625 1727	·599 5579	·847 9325	·533 7990	·631 2581	·584 1382	·845 6114	57
04	·530 1659	·625 2739	·599 2991	·847 8939	·533 8605	·631 3598	·583 8830	·845 5726	56
05	0·530 2276	0·625 3751	1·599 0404	0·847 8554	0·533 9220	0·631 4615	1·583 6278	0·845 5337	55
06	·530 2892	·625 4762	·598 7818	·847 8168	·533 9835	·631 5632	·583 3728	·845 4949	54
07	·530 3509	·625 5774	·598 5232	·847 7782	·534 0450	·631 6649	·583 1178	·845 4561	53
08	·530 4125	·625 6786	·598 2647	·847 7397	·534 1065	·631 7667	·582 8628	·845 4172	52
09	·530 4742	·625 7798	·598 0063	·847 7011	·534 1679	·631 8684	·582 6079	·845 3784	51
10	0·530 5358	0·625 8810	1·597 7479	0·847 6625	0·534 2294	0·631 9702	1·582 3531	0·845 3395	50
11	·530 5975	·625 9822	·597 4895	·847 6239	·534 2909	·632 0720	·582 0983	·845 3007	49
12	·530 6591	·626 0834	·597 2312	·847 5853	·534 3523	·632 1738	·581 8436	·845 2618	48
13	·530 7208	·626 1847	·596 9730	·847 5467	·534 4138	·632 2755	·581 5889	·845 2230	47
14	·530 7824	·626 2859	·596 7149	·847 5081	·534 4753	·632 3773	·581 3343	·845 1841	46
15	0·530 8440	0·626 3871	1·596 4568	0·847 4695	0·534 5367	0·632 4792	1·581 0798	0·845 1452	45
16	·530 9057	·626 4884	·596 1987	·847 4309	·534 5982	·632 5810	·580 8253	·845 1064	44
17	·530 9673	·626 5897	·595 9408	·847 3923	·534 6597	·632 6828	·580 5709	·845 0675	43
18	·531 0289	·626 6910	·595 6828	·847 3537	·534 7211	·632 7846	·580 3165	·845 0286	42
19	·531 0905	·626 7922	·595 4250	·847 3151	·534 7826	·632 8865	·580 0622	·844 9897	41
20	0·531 1521	0·626 8935	1·595 1672	0·847 2765	0·534 8440	0·632 9883	1·579 8079	0·844 9508	40
21	·531 2138	·626 9948	·594 9094	·847 2378	·534 9055	·633 0902	·579 5537	·844 9119	39
22	·531 2754	·627 0962	·594 6518	·847 1992	·534 9669	·633 1921	·579 2996	·844 8730	38
23	·531 3370	·627 1975	·594 3942	·847 1606	·535 0283	·633 2940	·579 0455	·844 8341	37
24	·531 3986	·627 2988	·594 1366	·847 1219	·535 0898	·633 3959	·578 7915	·844 7952	36
25	0·531 4602	0·627 4002	1·593 8791	0·847 0833	0·535 1512	0·633 4978	1·578 5376	0·844 7563	35
26	·531 5218	·627 5015	·593 6217	·847 0446	·535 2126	·633 5997	·578 2837	·844 7174	34
27	·531 5834	·627 6029	·593 3643	·847 0060	·535 2741	·633 7016	·578 0298	·844 6784	33
28	·531 6450	·627 7042	·593 1070	·846 9673	·535 3355	·633 8035	·577 7760	·844 6395	32
29	·531 7066	·627 8056	·592 8497	·846 9286	·535 3969	·633 9055	·577 5223	·844 6006	31
30	0·531 7682	0·627 9070	1·592 5925	0·846 8900	0·535 4583	0·634 0074	1·577 2686	0·844 5616	30
31	·531 8297	·628 0084	·592 3354	·846 8513	·535 5198	·634 1094	·577 0150	·844 5227	29
32	·531 8913	·628 1098	·592 0783	·846 8126	·535 5812	·634 2113	·576 7615	·844 4838	28
33	·531 9529	·628 2112	·591 8213	·846 7739	·535 6426	·634 3133	·576 5080	·844 4448	27
34	·532 0145	·628 3127	·591 5643	·846 7353	·535 7040	·634 4153	·576 2546	·844 4058	26
35	0·532 0761	0·628 4141	1·591 3074	0·846 6966	0·535 7654	0·634 5173	1·576 0012	0·844 3669	25
36	·532 1376	·628 5155	·591 0505	·846 6579	·535 8268	·634 6193	·575 7479	·844 3279	24
37	·532 1992	·628 6170	·590 7938	·846 6192	·535 8882	·634 7213	·575 4946	·844 2890	23
38	·532 2608	·628 7185	·590 5370	·846 5805	·535 9496	·634 8233	·575 2414	·844 2500	22
39	·532 3223	·628 8199	·590 2804	·846 5418	·536 0110	·634 9254	·574 9883	·844 2110	21
40	0·532 3839	0·628 9214	1·590 0238	0·846 5030	0·536 0724	0·635 0274	1·574 7352	0·844 1720	20
41	·532 4454	·629 0229	·589 7672	·846 4643	·536 1338	·635 1295	·574 4821	·844 1330	19
42	·532 5070	·629 1244	·589 5107	·846 4256	·536 1952	·635 2315	·574 2292	·844 0940	18
43	·532 5686	·629 2259	·589 2543	·846 3869	·536 2565	·635 3336	·573 9763	·844 0551	17
44	·532 6301	·629 3274	·588 9979	·846 3481	·536 3179	·635 4357	·573 7234	·844 0161	16
45	0·532 6917	0·629 4290	1·588 7416	0·846 3094	0·536 3793	0·635 5378	1·573 4706	0·843 9770	15
46	·532 7532	·629 5305	·588 4854	·846 2707	·536 4407	·635 6399	·573 2179	·843 9380	14
47	·532 8147	·629 6321	·588 2292	·846 2319	·536 5020	·635 7420	·572 9652	·843 8990	13
48	·532 8763	·629 7336	·587 9731	·846 1932	·536 5634	·635 8441	·572 7126	·843 8600	12
49	·532 9378	·629 8352	·587 7170	·846 1544	·536 6248	·635 9462	·572 4600	·843 8210	11
50	0·532 9993	0·629 9367	1·587 4610	0·846 1157	0·536 6861	0·636 0484	1·572 2075	0·843 7820	10
51	·533 0609	·630 0383	·587 2050	·846 0769	·536 7475	·636 1505	·571 9550	·843 7429	09
52	·533 1224	·630 1399	·586 9491	·846 0381	·536 8089	·636 2527	·571 7026	·843 7039	08
53	·533 1839	·630 2415	·586 6933	·845 9994	·536 8702	·636 3548	·571 4503	·843 6649	07
54	·533 2454	·630 3431	·586 4375	·845 9606	·536 9316	·636 4570	·571 1980	·843 6258	06
55	0·533 3070	0·630 4448	1·586 1818	0·845 9218	0·536 9929	0·636 5592	1·570 9458	0·843 5868	05
56	·533 3685	·630 5464	·585 9261	·845 8830	·537 0543	·636 6614	·570 6936	·843 5477	04
57	·533 4300	·630 6480	·585 6705	·845 8442	·537 1156	·636 7636	·570 4415	·843 5086	03
58	·533 4915	·630 7497	·585 4150	·845 8054	·537 1769	·636 8658	·570 1895	·843 4696	02
59	·533 5530	·630 8513	·585 1595	·845 7666	·537 2383	·636 9680	·569 9375	·843 4305	01
60	0·533 6145	0·630 9530	1·584 9041	0·845 7278	0·537 2996	0·637 0703	1·569 6856	0·843 3914	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	615–617	1017–1011	2554–2589	388–385	613–615	1023–1017	2519–2554	391–388	d

$3^{h}\ 51^{m}$ $3^{h}\ 50^{m}$

$2^h\ 10^m$ $2^h\ 11^m$

d	614–611	1022–1028	2519–2485	390–394	612–609	1028–1034	2484–2452	393–396	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·537 2996	0·637 0703	1·569 6856	0·843 3914	0·540 9745	0·643 2216	1·554 6741	0·841 0390	60
01	·537 3609	·637 1725	·569 4337	·843 3524	·541 0356	·643 3244	·554 4257	·840 9997	59
02	·537 4223	·637 2748	·569 1819	·843 3133	·541 0968	·643 4273	·554 1773	·840 9603	58
03	·537 4836	·637 3770	·568 9301	·843 2742	·541 1579	·643 5301	·553 9289	·840 9210	57
04	·537 5449	·637 4793	·568 6784	·843 2351	·541 2191	·643 6329	·553 6806	·840 8816	56
05	0·537 6062	0·637 5816	1·568 4268	0·843 1960	0·541 2802	0·643 7358	1·553 4324	0·840 8423	55
06	·537 6676	·637 6839	·568 1752	·843 1569	·541 3414	·643 8386	·553 1842	·840 8029	54
07	·537 7289	·637 7862	·567 9237	·843 1178	·541 4025	·643 9415	·552 9361	·840 7635	53
08	·537 7902	·637 8885	·567 6722	·843 0787	·541 4637	·644 0444	·552 6880	·840 7241	52
09	·537 8515	·637 9908	·567 4208	·843 0396	·541 5248	·644 1473	·552 4400	·840 6848	51
10	0·537 9128	0·638 0931	1·567 1694	0·843 0005	0·541 5859	0·644 2502	1·552 1920	0·840 6454	50
11	·537 9741	·638 1954	·566 9181	·842 9614	·541 6471	·644 3531	·551 9441	·840 6060	49
12	·538 0354	·638 2978	·566 6669	·842 9222	·541 7082	·644 4560	·551 6963	·840 5666	48
13	·538 0967	·638 4001	·566 4157	·842 8831	·541 7693	·644 5590	·551 4485	·840 5272	47
14	·538 1580	·638 5025	·566 1646	·842 8440	·541 8305	·644 6619	·551 2007	·840 4878	46
15	0·538 2193	0·638 6049	1·565 9135	0·842 8048	0·541 8916	0·644 7648	1·550 9531	0·840 4484	45
16	·538 2806	·638 7073	·565 6625	·842 7657	·541 9527	·644 8678	·550 7054	·840 4090	44
17	·538 3419	·638 8097	·565 4115	·842 7266	·542 0138	·644 9708	·550 4579	·840 3696	43
18	·538 4031	·638 9121	·565 1606	·842 6874	·542 0749	·645 0737	·550 2103	·840 3302	42
19	·538 4644	·639 0145	·564 9098	·842 6482	·542 1360	·645 1767	·549 9629	·840 2907	41
20	0·538 5257	0·639 1169	1·564 6590	0·842 6091	0·542 1971	0·645 2797	1·549 7155	0·840 2513	40
21	·538 5870	·639 2193	·564 4083	·842 5699	·542 2582	·645 3827	·549 4681	·840 2119	39
22	·538 6482	·639 3218	·564 1576	·842 5307	·542 3193	·645 4858	·549 2209	·840 1724	38
23	·538 7095	·639 4242	·563 9070	·842 4916	·542 3804	·645 5888	·548 9736	·840 1330	37
24	·538 7708	·639 5267	·563 6564	·842 4524	·542 4415	·645 6918	·548 7264	·840 0936	36
25	0·538 8320	0·639 6292	1·563 4059	0·842 4132	0·542 5026	0·645 7949	1·548 4793	0·840 0541	35
26	·538 8933	·639 7316	·563 1555	·842 3740	·542 5637	·645 8979	·548 2323	·840 0147	34
27	·538 9546	·639 8341	·562 9051	·842 3348	·542 6248	·646 0010	·547 9852	·839 9752	33
28	·539 0158	·639 9366	·562 6548	·842 2956	·542 6859	·646 1041	·547 7383	·839 9357	32
29	·539 0771	·640 0391	·562 4045	·842 2564	·542 7470	·646 2071	·547 4914	·839 8963	31
30	0·539 1383	0·640 1416	1·562 1543	0·842 2172	0·542 8080	0·646 3102	1·547 2445	0·839 8568	30
31	·539 1996	·640 2442	·561 9041	·842 1780	·542 8691	·646 4133	·546 9978	·839 8173	29
32	·539 2608	·640 3467	·561 6540	·842 1388	·542 9302	·646 5165	·546 7510	·839 7778	28
33	·539 3221	·640 4493	·561 4040	·842 0996	·542 9913	·646 6196	·546 5044	·839 7383	27
34	·539 3833	·640 5518	·561 1540	·842 0604	·543 0523	·646 7227	·546 2577	·839 6989	26
35	0·539 4445	0·640 6544	1·560 9040	0·842 0211	0·543 1134	0·646 8259	1·546 0112	0·839 6594	25
36	·539 5058	·640 7569	·560 6542	·841 9819	·543 1744	·646 9290	·545 7647	·839 6199	24
37	·539 5670	·640 8595	·560 4043	·841 9427	·543 2355	·647 0322	·545 5182	·839 5804	23
38	·539 6282	·640 9621	·560 1546	·841 9034	·543 2966	·647 1353	·545 2718	·839 5409	22
39	·539 6894	·641 0647	·559 9049	·841 8642	·543 3576	·647 2385	·545 0255	·839 5013	21
40	0·539 7507	0·641 1673	1·559 6552	0·841 8249	0·543 4187	0·647 3417	1·544 7792	0·839 4618	20
41	·539 8119	·641 2700	·559 4056	·841 7857	·543 4797	·647 4449	·544 5329	·839 4223	19
42	·539 8731	·641 3726	·559 1561	·841 7464	·543 5408	·647 5481	·544 2867	·839 3828	18
43	·539 9343	·641 4752	·558 9066	·841 7072	·543 6018	·647 6514	·544 0406	·839 3433	17
44	·539 9955	·641 5779	·558 6572	·841 6679	·543 6628	·647 7546	·543 7946	·839 3037	16
45	0·540 0567	0·641 6806	1·558 4078	0·841 6286	0·543 7239	0·647 8578	1·543 5485	0·839 2642	15
46	·540 1179	·641 7832	·558 1585	·841 5893	·543 7849	·647 9611	·543 3026	·839 2246	14
47	·540 1791	·641 8859	·557 9093	·841 5501	·543 8459	·648 0643	·543 0567	·839 1851	13
48	·540 2403	·641 9886	·557 6601	·841 5108	·543 9069	·648 1676	·542 8108	·839 1455	12
49	·540 3015	·642 0913	·557 4109	·841 4715	·543 9680	·648 2709	·542 5650	·839 1060	11
50	0·540 3627	0·642 1940	1·557 1619	0·841 4322	0·544 0290	0·648 3742	1·542 3193	0·839 0664	10
51	·540 4239	·642 2967	·556 9128	·841 3929	·544 0900	·648 4775	·542 0736	·839 0269	09
52	·540 4851	·642 3994	·556 6639	·841 3536	·544 1510	·648 5808	·541 8280	·838 9873	08
53	·540 5463	·642 5022	·556 4149	·841 3143	·544 2120	·648 6841	·541 5824	·838 9477	07
54	·540 6074	·642 6049	·556 1661	·841 2750	·544 2730	·648 7874	·541 3369	·838 9081	06
55	0·540 6686	0·642 7077	1·555 9173	0·841 2357	0·544 3340	0·648 8908	1·541 0914	0·838 8685	05
56	·540 7298	·642 8105	·555 6685	·841 1963	·544 3951	·648 9941	·540 8460	·838 8290	04
57	·540 7910	·642 9132	·555 4199	·841 1570	·544 4561	·649 0975	·540 6007	·838 7894	03
58	·540 8521	·643 0160	·555 1712	·841 1177	·544 5170	·649 2008	·540 3554	·838 7498	02
59	·540 9133	·643 1188	·554 9226	·841 0784	·544 5780	·649 3042	·540 1102	·838 7102	01
60	0·540 9745	0·643 2216	1·554 6741	0·841 0390	0·544 6390	0·649 4076	1·539 8650	0·838 6706	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	611–614	1028–1022	2485–2519	394–390	609–612	1034–1028	2452–2484	396–393	d

$3^h\ 49^m$ $3^h\ 48^m$

$2^{h}\ 12^{m}$ $2^{h}\ 13^{m}$

d	610–608	1034–1040	2452–2419	396–399	609–606	1040–1046	2419–2387	399–402	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·544 6390	0·649 4076	1·539 8650	0·838 6706	0·548 2932	0·655 6287	1·525 2535	0·836 2862	60
01	·544 7000	·649 5110	·539 6198	·838 6310	·548 3540	·655 7327	·525 0116	·836 2463	59
02	·544 7610	·649 6144	·539 3748	·838 5913	·548 4149	·655 8367	·524 7698	·836 2064	58
03	·544 8220	·649 7178	·539 1297	·838 5517	·548 4757	·655 9407	·524 5280	·836 1665	57
04	·544 8830	·649 8212	·538 8848	·838 5121	·548 5365	·656 0447	·524 2863	·836 1266	56
05	0·544 9439	0·649 9247	1·538 6399	0·838 4725	0·548 5973	0·656 1488	1·524 0446	0·836 0867	55
06	·545 0049	·650 0281	·538 3950	·838 4328	·548 6581	·656 2528	·523 8030	·836 0468	54
07	·545 0659	·650 1316	·538 1502	·838 3932	·548 7189	·656 3568	·523 5615	·836 0069	53
08	·545 1269	·650 2350	·537 9054	·838 3536	·548 7797	·656 4609	·523 3200	·835 9670	52
09	·545 1878	·650 3385	·537 6608	·838 3139	·548 8405	·656 5650	·523 0785	·835 9271	51
10	0·545 2488	0·650 4420	1·537 4161	0·838 2743	0·548 9012	0·656 6690	1·522 8371	0·835 8872	50
11	·545 3097	·650 5455	·537 1715	·838 2346	·548 9620	·656 7731	·522 5958	·835 8473	49
12	·545 3707	·650 6490	·536 9270	·838 1950	·549 0228	·656 8772	·522 3545	·835 8074	48
13	·545 4317	·650 7525	·536 6825	·838 1553	·549 0836	·656 9813	·522 1133	·835 7674	47
14	·545 4926	·650 8560	·536 4381	·838 1156	·549 1444	·657 0854	·521 8721	·835 7275	46
15	0·545 5536	0·650 9596	1·536 1937	0·838 0760	0·549 2051	0·657 1896	1·521 6310	0·835 6876	45
16	·545 6145	·651 0631	·535 9494	·838 0363	·549 2659	·657 2937	·521 3899	·835 6476	44
17	·545 6754	·651 1667	·535 7052	·837 9966	·549 3267	·657 3979	·521 1489	·835 6077	43
18	·545 7364	·651 2702	·535 4610	·837 9569	·549 3875	·657 5020	·520 9079	·835 5677	42
19	·545 7973	·651 3738	·535 2168	·837 9172	·549 4482	·657 6062	·520 6670	·835 5278	41
20	0·545 8583	0·651 4774	1·534 9727	0·837 8775	0·549 5090	0·657 7103	1·520 4261	0·835 4878	40
21	·545 9192	·651 5810	·534 7287	·837 8378	·549 5697	·657 8145	·520 1853	·835 4478	39
22	·545 9801	·651 6846	·534 4847	·837 7981	·549 6305	·657 9187	·519 9446	·835 4079	38
23	·546 0410	·651 7882	·534 2408	·837 7584	·549 6912	·658 0229	·519 7039	·835 3679	37
24	·546 1020	·651 8918	·533 9969	·837 7187	·549 7520	·658 1271	·519 4632	·835 3279	36
25	0·546 1629	0·651 9954	1·533 7531	0·837 6790	0·549 8127	0·658 2314	1·519 2226	0·835 2879	35
26	·546 2238	·652 0991	·533 5093	·837 6393	·549 8735	·658 3356	·518 9821	·835 2480	34
27	·546 2847	·652 2027	·533 2656	·837 5996	·549 9342	·658 4399	·518 7416	·835 2080	33
28	·546 3456	·652 3064	·533 0219	·837 5598	·549 9950	·658 5441	·518 5012	·835 1680	32
29	·546 4065	·652 4101	·532 7783	·837 5201	·550 0557	·658 6484	·518 2608	·835 1280	31
30	0·546 4674	0·652 5137	1·532 5348	0·837 4804	0·550 1164	0·658 7526	1·518 0205	0·835 0880	30
31	·546 5283	·652 6174	·532 2913	·837 4406	·550 1771	·658 8569	·517 7802	·835 0480	29
32	·546 5892	·652 7211	·532 0479	·837 4009	·550 2379	·658 9612	·517 5400	·835 0080	28
33	·546 6501	·652 8248	·531 8045	·837 3611	·550 2986	·659 0655	·517 2998	·834 9679	27
34	·546 7110	·652 9286	·531 5611	·837 3214	·550 3593	·659 1698	·517 0597	·834 9279	26
35	0·546 7719	0·653 0323	1·531 3179	0·837 2816	0·550 4200	0·659 2742	1·516 8196	0·834 8879	25
36	·546 8328	·653 1360	·531 0746	·837 2418	·550 4807	·659 3785	·516 5796	·834 8479	24
37	·546 8937	·653 2398	·530 8315	·837 2021	·550 5415	·659 4829	·516 3396	·834 8078	23
38	·546 9546	·653 3435	·530 5884	·837 1623	·550 6022	·659 5872	·516 0997	·834 7678	22
39	·547 0154	·653 4473	·530 3453	·837 1225	·550 6629	·659 6916	·515 8599	·834 7277	21
40	0·547 0763	0·653 5511	1·530 1023	0·837 0827	0·550 7236	0·659 7960	1·515 6201	0·834 6877	20
41	·547 1372	·653 6549	·529 8593	·837 0429	·550 7843	·659 9003	·515 3803	·834 6476	19
42	·547 1981	·653 7587	·529 6164	·837 0032	·550 8450	·660 0047	·515 1407	·834 6076	18
43	·547 2589	·653 8625	·529 3736	·836 9634	·550 9057	·660 1091	·514 9010	·834 5675	17
44	·547 3198	·653 9663	·529 1308	·836 9236	·550 9663	·660 2136	·514 6614	·834 5275	16
45	0·547 3807	0·654 0701	1·528 8881	0·836 8838	0·551 0270	0·660 3180	1·514 4219	0·834 4874	15
46	·547 4415	·654 1740	·528 6454	·836 8439	·551 0877	·660 4224	·514 1824	·834 4473	14
47	·547 5024	·654 2778	·528 4028	·836 8041	·551 1484	·660 5269	·513 9430	·834 4072	13
48	·547 5632	·654 3817	·528 1602	·836 7643	·551 2091	·660 6313	·513 7036	·834 3672	12
49	·547 6241	·654 4855	·527 9177	·836 7245	·551 2697	·660 7358	·513 4643	·834 3271	11
50	0·547 6849	0·654 5894	1·527 6752	0·836 6847	0·551 3304	0·660 8403	1·513 2250	0·834 2870	10
51	·547 7458	·654 6933	·527 4328	·836 6448	·551 3911	·660 9447	·512 9858	·834 2469	09
52	·547 8066	·654 7972	·527 1904	·836 6050	·551 4518	·661 0492	·512 7466	·834 2068	08
53	·547 8674	·654 9011	·526 9481	·836 5652	·551 5124	·661 1537	·512 5075	·834 1667	07
54	·547 9283	·655 0050	·526 7059	·836 5253	·551 5731	·661 2583	·512 2685	·834 1266	06
55	0·547 9891	0·655 1089	1·526 4637	0·836 4855	0·551 6337	0·661 3628	1·512 0294	0·834 0865	05
56	·548 0499	·655 2129	·526 2215	·836 4456	·551 6944	·661 4673	·511 7905	·834 0463	04
57	·548 1108	·655 3168	·525 9794	·836 4058	·551 7550	·661 5719	·511 5516	·834 0062	03
58	·548 1716	·655 4208	·525 7374	·836 3659	·551 8157	·661 6764	·511 3127	·833 9661	02
59	·548 2324	·655 5248	·525 4954	·836 3260	·551 8763	·661 7810	·511 0739	·833 9260	01
60	0·548 2932	0·655 6287	1·525 2535	0·836 2862	0·551 9370	0·661 8856	1·510 8352	0·833 8858	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	608–610	1040–1034	2419–2452	399–396	606–609	1046–1040	2387–2419	402–399	d

$3^{h}\ 47^{m}$ $3^{h}\ 46^{m}$

$2^h\ 14^m$ $2^h\ 15^m$

d	607–604	1045–1052	2387–2356	401–404	605–603	1052–1058	2356–2326	404–407	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·551 9370	0·661 8856	1·510 8352	0·833 8858	0·555 5702	0·668 1786	1·496 6058	0·831 4696	60
01	·551 9976	·661 9901	·510 5965	·833 8457	·555 6307	·668 2838	·496 3702	·831 4292	59
02	·552 0583	·662 0947	·510 3579	·833 8055	·555 6912	·668 3890	·496 1347	·831 3888	58
03	·552 1189	·662 1993	·510 1193	·833 7654	·555 7516	·668 4943	·495 8992	·831 3484	57
04	·552 1795	·662 3040	·509 8807	·833 7252	·555 8121	·668 5995	·495 6637	·831 3080	56
05	0·552 2402	0·662 4086	1·509 6423	0·833 6851	0·555 8725	0·668 7047	1·495 4284	0·831 2675	55
06	·552 3008	·662 5132	·509 4038	·833 6449	·555 9330	·668 8100	·495 1930	·831 2271	54
07	·552 3614	·662 6179	·509 1654	·833 6047	·555 9934	·668 9152	·494 9578	·831 1867	53
08	·552 4220	·662 7225	·508 9271	·833 5646	·556 0539	·669 0205	·494 7225	·831 1463	52
09	·552 4826	·662 8272	·508 6888	·833 5244	·556 1143	·669 1258	·494 4874	·831 1058	51
10	0·552 5433	0·662 9319	1·508 4506	0·833 4842	0·556 1747	0·669 2310	1·494 2523	0·831 0654	50
11	·552 6039	·663 0366	·508 2125	·833 4440	·556 2352	·669 3363	·494 0172	·831 0249	49
12	·552 6645	·663 1413	·507 9743	·833 4038	·556 2956	·669 4417	·493 7822	·830 9845	48
13	·552 7251	·663 2460	·507 7363	·833 3637	·556 3560	·669 5470	·493 5472	·830 9440	47
14	·552 7857	·663 3507	·507 4983	·833 3235	·556 4165	·669 6523	·493 3123	·830 9036	46
15	0·552 8463	0·663 4554	1·507 2603	0·833 2833	0·556 4769	0·669 7576	1·493 0774	0·830 8631	45
16	·552 9069	·663 5601	·507 0224	·833 2430	·556 5373	·669 8630	·492 8426	·830 8226	44
17	·552 9675	·663 6649	·506 7845	·833 2028	·556 5977	·669 9683	·492 6078	·830 7821	43
18	·553 0281	·663 7697	·506 5467	·833 1626	·556 6581	·670 0737	·492 3731	·830 7417	42
19	·553 0887	·663 8744	·506 3090	·833 1224	·556 7186	·670 1791	·492 1385	·830 7012	41
20	0·553 1492	0·663 9792	1·506 0713	0·833 0822	0·556 7790	0·670 2845	1·491 9039	0·830 6607	40
21	·553 2098	·664 0840	·505 8336	·833 0420	·556 8394	·670 3899	·491 6693	·830 6202	39
22	·553 2704	·664 1888	·505 5960	·833 0017	·556 8998	·670 4953	·491 4348	·830 5797	38
23	·553 3310	·664 2936	·505 3585	·832 9615	·556 9602	·670 6007	·491 2003	·830 5392	37
24	·553 3915	·664 3984	·505 1210	·832 9212	·557 0206	·670 7061	·490 9659	·830 4987	36
25	0·553 4521	0·664 5032	1·504 8836	0·832 8810	0·557 0810	0·670 8116	1·490 7316	0·830 4582	35
26	·553 5127	·664 6081	·504 6462	·832 8407	·557 1414	·670 9170	·490 4973	·830 4177	34
27	·553 5733	·664 7129	·504 4088	·832 8005	·557 2017	·671 0225	·490 2630	·830 3772	33
28	·553 6338	·664 8178	·504 1716	·832 7602	·557 2621	·671 1280	·490 0288	·830 3366	32
29	·553 6944	·664 9227	·503 9343	·832 7200	·557 3225	·671 2334	·489 7946	·830 2961	31
30	0·553 7549	0·665 0275	1·503 6971	0·832 6797	0·557 3829	0·671 3389	1·489 5605	0·830 2556	30
31	·553 8155	·665 1324	·503 4600	·832 6394	·557 4433	·671 4444	·489 3265	·830 2150	29
32	·553 8760	·665 2373	·503 2229	·832 5991	·557 5036	·671 5500	·489 0925	·830 1745	28
33	·553 9366	·665 3422	·502 9859	·832 5589	·557 5640	·671 6555	·488 8585	·830 1339	27
34	·553 9971	·665 4472	·502 7489	·832 5186	·557 6244	·671 7610	·488 6246	·830 0934	26
35	0·554 0577	0·665 5521	1·502 5120	0·832 4783	0·557 6847	0·671 8666	1·488 3908	0·830 0528	25
36	·554 1182	·665 6570	·502 2751	·832 4380	·557 7451	·671 9721	·488 1570	·830 0123	24
37	·554 1787	·665 7620	·502 0383	·832 3977	·557 8055	·672 0777	·487 9232	·829 9717	23
38	·554 2393	·665 8669	·501 8016	·832 3574	·557 8658	·672 1833	·487 6895	·829 9312	22
39	·554 2998	·665 9719	·501 5648	·832 3171	·557 9262	·672 2888	·487 4559	·829 8906	21
40	0·554 3603	0·666 0769	1·501 3282	0·832 2768	0·557 9865	0·672 3944	1·487 2223	0·829 8500	20
41	·554 4208	·666 1819	·501 0916	·832 2365	·558 0469	·672 5000	·486 9888	·829 8094	19
42	·554 4814	·666 2869	·500 8550	·832 1961	·558 1072	·672 6057	·486 7553	·829 7688	18
43	·554 5419	·666 3919	·500 6185	·832 1558	·558 1676	·672 7113	·486 5218	·829 7283	17
44	·554 6024	·666 4969	·500 3821	·832 1155	·558 2279	·672 8169	·486 2884	·829 6877	16
45	0·554 6629	0·666 6019	1·500 1456	0·832 0752	0·558 2882	0·672 9226	1·486 0551	0·829 6471	15
46	·554 7234	·666 7070	·499 9093	·832 0348	·558 3486	·673 0282	·485 8218	·829 6065	14
47	·554 7839	·666 8120	·499 6730	·831 9945	·558 4089	·673 1339	·485 5885	·829 5659	13
48	·554 8444	·666 9171	·499 4367	·831 9541	·558 4692	·673 2396	·485 3554	·829 5252	12
49	·554 9049	·667 0222	·499 2005	·831 9138	·558 5295	·673 3453	·485 1222	·829 4846	11
50	0·554 9654	0·667 1273	1·498 9644	0·831 8734	0·558 5899	0·673 4510	1·484 8891	0·829 4440	10
51	·555 0259	·667 2323	·498 7283	·831 8331	·558 6502	·673 5567	·484 6561	·829 4034	09
52	·555 0864	·667 3374	·498 4923	·831 7927	·558 7105	·673 6624	·484 4231	·829 3628	08
53	·555 1469	·667 4426	·498 2563	·831 7523	·558 7708	·673 7681	·484 1901	·829 3221	07
54	·555 2074	·667 5477	·498 0203	·831 7119	·558 8311	·673 8739	·483 9573	·829 2815	06
55	0·555 2679	0·667 6528	1·497 7844	0·831 6716	0·558 8914	0·673 9796	1·483 7244	0·829 2408	05
56	·555 3283	·667 7580	·497 5486	·831 6312	·558 9517	·674 0854	·483 4916	·829 2002	04
57	·555 3888	·667 8631	·497 3128	·831 5908	·559 0120	·674 1911	·483 2589	·829 1595	03
58	·555 4493	·667 9683	·497 0771	·831 5504	·559 0723	·674 2969	·483 0262	·829 1189	02
59	·555 5098	·668 0735	·496 8414	·831 5100	·559 1326	·674 4027	·482 7936	·829 0782	01
60	0·555 5702	0·668 1786	1·496 6058	0·831 4696	0·559 1929	0·674 5085	1·482 5610	0·829 0376	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	604–607	1052–1045	2356–2387	404–401	603–605	1058–1052	2326–2356	407–404	d

$3^h\ 45^m$ $3^h\ 44^m$

2ʰ 16ᵐ 2ʰ 17ᵐ

d	603–601	1058–1065	2326–2296	406–410	601–599	1064–1071	2296–2267	409–412	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·559 1929	0·674 5085	1·482 5610	0·829 0376	0·562 8049	0·680 8758	1·468 6967	0·826 5897	60
01	·559 2532	·674 6143	·482 3284	·828 9969	·562 8650	·680 9822	·468 4672	·826 5488	59
02	·559 3135	·674 7202	·482 0959	·828 9562	·562 9251	·681 0887	·468 2376	·826 5079	58
03	·559 3738	·674 8260	·481 8635	·828 9156	·562 9852	·681 1951	·468 0082	·826 4669	57
04	·559 4340	·674 9318	·481 6311	·828 8749	·563 0453	·681 3016	·467 7788	·826 4260	56
05	0·559 4943	0·675 0377	1·481 3988	0·828 8342	0·563 1054	0·681 4081	1·467 5494	0·826 3851	55
06	·559 5546	·675 1436	·481 1665	·828 7935	·563 1655	·681 5146	·467 3201	·826 3441	54
07	·559 6149	·675 2494	·480 9342	·828 7528	·563 2256	·681 6211	·467 0908	·826 3031	53
08	·559 6751	·675 3553	·480 7021	·828 7121	·563 2857	·681 7276	·466 8616	·826 2622	52
09	·559 7354	·675 4612	·480 4699	·828 6714	·563 3458	·681 8341	·466 6324	·826 2212	51
10	0·559 7956	0·675 5671	1·480 2378	0·828 6307	0·563 4059	0·681 9406	1·466 4033	0·826 1802	50
11	·559 8559	·675 6730	·480 0058	·828 5900	·563 4660	·682 0472	·466 1742	·826 1393	49
12	·559 9162	·675 7790	·479 7738	·828 5493	·563 5260	·682 1537	·465 9452	·826 0983	48
13	·559 9764	·675 8849	·479 5419	·828 5085	·563 5861	·682 2603	·465 7162	·826 0573	47
14	·560 0367	·675 9908	·479 3100	·828 4678	·563 6462	·682 3669	·465 4873	·826 0163	46
15	0·560 0969	0·676 0968	1·479 0781	0·828 4271	0·563 7063	0·682 4735	1·465 2584	0·825 9753	45
16	·560 1572	·676 2028	·478 8463	·828 3864	·563 7663	·682 5801	·465 0296	·825 9343	44
17	·560 2174	·676 3088	·478 6146	·828 3456	·563 8264	·682 6867	·464 8008	·825 8933	43
18	·560 2776	·676 4147	·478 3829	·828 3049	·563 8864	·682 7933	·464 5720	·825 8523	42
19	·560 3379	·676 5207	·478 1513	·828 2641	·563 9465	·682 8999	·464 3434	·825 8113	41
20	0·560 3981	0·676 6268	1·477 9197	0·828 2234	0·564 0066	0·683 0066	1·464 1147	0·825 7703	40
21	·560 4583	·676 7328	·477 6881	·828 1826	·564 0666	·683 1132	·463 8861	·825 7293	39
22	·560 5186	·676 8388	·477 4567	·828 1419	·564 1267	·683 2199	·463 6576	·825 6883	38
23	·560 5788	·676 9448	·477 2252	·828 1011	·564 1867	·683 3266	·463 4291	·825 6472	37
24	·560 6390	·677 0509	·476 9938	·828 0603	·564 2467	·683 4333	·463 2007	·825 6062	36
25	0·560 6992	0·677 1570	1·476 7625	0·828 0196	0·564 3068	0·683 5400	1·462 9723	0·825 5652	35
26	·560 7594	·677 2630	·476 5312	·827 9788	·564 3668	·683 6467	·462 7439	·825 5241	34
27	·560 8196	·677 3691	·476 3000	·827 9380	·564 4268	·683 7534	·462 5156	·825 4831	33
28	·560 8798	·677 4752	·476 0688	·827 8972	·564 4869	·683 8601	·462 2874	·825 4420	32
29	·560 9400	·677 5813	·475 8376	·827 8564	·564 5469	·683 9668	·462 0592	·825 4010	31
30	0·561 0003	0·677 6874	1·475 6065	0·827 8156	0·564 6069	0·684 0736	1·461 8310	0·825 3599	30
31	·561 0604	·677 7936	·475 3755	·827 7748	·564 6669	·684 1803	·461 6029	·825 3189	29
32	·561 1206	·677 8997	·475 1445	·827 7340	·564 7270	·684 2871	·461 3749	·825 2778	28
33	·561 1808	·678 0058	·474 9135	·827 6932	·564 7870	·684 3939	·461 1469	·825 2367	27
34	·561 2410	·678 1120	·474 6826	·827 6524	·564 8470	·684 5007	·460 9189	·825 1957	26
35	0·561 3012	0·678 2182	1·474 4518	0·827 6116	0·564 9070	0·684 6075	1·460 6910	0·825 1546	25
36	·561 3614	·678 3243	·474 2210	·827 5708	·564 9670	·684 7143	·460 4632	·825 1135	24
37	·561 4216	·678 4305	·473 9903	·827 5299	·565 0270	·684 8211	·460 2354	·825 0724	23
38	·561 4818	·678 5367	·473 7596	·827 4891	·565 0870	·684 9279	·460 0076	·825 0313	22
39	·561 5419	·678 6429	·473 5289	·827 4483	·565 1470	·685 0348	·459 7799	·824 9902	21
40	0·561 6021	0·678 7492	1·473 2983	0·827 4074	0·565 2070	0·685 1416	1·459 5522	0·824 9491	20
41	·561 6623	·678 8554	·473 0678	·827 3666	·565 2670	·685 2485	·459 3246	·824 9080	19
42	·561 7224	·678 9616	·472 8373	·827 3258	·565 3270	·685 3554	·459 0970	·824 8669	18
43	·561 7826	·679 0679	·472 6068	·827 2849	·565 3870	·685 4623	·458 8695	·824 8258	17
44	·561 8428	·679 1741	·472 3764	·827 2440	·565 4469	·685 5692	·458 6420	·824 7847	16
45	0·561 9029	0·679 2804	1·472 1461	0·827 2032	0·565 5069	0·685 6761	1·458 4146	0·824 7436	15
46	·561 9631	·679 3867	·471 9158	·827 1623	·565 5669	·685 7830	·458 1872	·824 7024	14
47	·562 0232	·679 4930	·471 6855	·827 1214	·565 6269	·685 8899	·457 9599	·824 6613	13
48	·562 0834	·679 5993	·471 4553	·827 0806	·565 6868	·685 9969	·457 7326	·824 6202	12
49	·562 1435	·679 7056	·471 2252	·827 0397	·565 7468	·686 1038	·457 5054	·824 5790	11
50	0·562 2037	0·679 8119	1·470 9951	0·826 9988	0·565 8068	0·686 2108	1·457 2782	0·824 5379	10
51	·562 2638	·679 9183	·470 7650	·826 9579	·565 8667	·686 3177	·457 0511	·824 4967	09
52	·562 3239	·680 0246	·470 5350	·826 9170	·565 9267	·686 4247	·456 8240	·824 4556	08
53	·562 3841	·680 1310	·470 3050	·826 8761	·565 9866	·686 5317	·456 5970	·824 4144	07
54	·562 4442	·680 2373	·470 0751	·826 8352	·566 0466	·686 6387	·456 3700	824 3733	06
55	0·562 5043	0·680 3437	1·469 8453	0·826 7943	0·566 1065	0·686 7457	1·456 1430	0·824 3321	05
56	·562 5645	·680 4501	·469 6155	·826 7534	·566 1665	·686 8528	·455 9161	·824 2909	04
57	·562 6246	·680 5565	·469 3857	·826 7125	·566 2264	·686 9598	·455 6893	·824 2497	03
58	·562 6847	·680 6629	·469 1560	·826 6716	·566 2864	·687 0668	·455 4625	·824 2086	02
59	·562 7448	·680 7693	·468 9263	·826 6307	·566 3463	·687 1739	·455 2357	·824 1674	01
60	0·562 8049	0·680 8758	1·468 6967	0·826 5897	0·566 4062	0·687 2810	1·455 0090	0·824 1262	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	601–603	1065–1058	2296–2326	410–406	599–601	1071–1064	2267–2296	412–409	d

3ʰ 43ᵐ 3ʰ 42ᵐ

$2^h\ 18^m$ $2^h\ 19^m$

d	600–597	1070–1077	2266–2239	412–415	598–595	1077–1084	2238–2211	414–418	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·566 4062	0·687 2810	1·455 0090	0·824 1262	0·569 9968	0·693 7247	1·441 4940	0·821 6469	60
01	·566 4662	·687 3880	·454 7824	·824 0850	·570 0565	·693 8324	·441 2702	·821 6055	59
02	·566 5261	·687 4951	·454 5558	·824 0438	·570 1163	·693 9401	·441 0465	·821 5640	58
03	·566 5860	·687 6022	·454 3292	·824 0026	·570 1760	·694 0479	·440 8228	·821 5226	57
04	·566 6459	·687 7093	·454 1027	·823 9614	·570 2357	·694 1557	·440 5991	·821 4811	56
05	0·566 7059	0·687 8165	1·453 8762	0·823 9202	0·570 2955	0·694 2634	1·440 3755	0·821 4396	55
06	·566 7658	·687 9236	·453 6498	·823 8790	·570 3552	·694 3712	·440 1519	·821 3981	54
07	·566 8257	·688 0307	·453 4235	·823 8378	·570 4150	·694 4790	·439 9284	·821 3567	53
08	·566 8856	·688 1379	·453 1971	·823 7965	·570 4747	·694 5868	·439 7049	·821 3152	52
09	·566 9455	·688 2450	·452 9709	·823 7553	·570 5344	·694 6946	·439 4815	·821 2737	51
10	0·567 0054	0·688 3522	1·452 7446	0·823 7141	0·570 5941	0·694 8024	1·439 2581	0·821 2322	50
11	·567 0653	·688 4594	·452 5185	·823 6728	·570 6539	·694 9103	·439 0347	·821 1907	49
12	·567 1252	·688 5666	·452 2923	·823 6316	·570 7136	·695 0181	·438 8114	·821 1492	48
13	·567 1851	·688 6738	·452 0663	·823 5903	·570 7733	·695 1260	·438 5882	·821 1077	47
14	·567 2450	·688 7810	·451 8402	·823 5491	·570 8330	·695 2338	·438 3650	·821 0662	46
15	0·567 3049	0·688 8883	1·451 6142	0·823 5078	0·570 8927	0·695 3417	1·438 1418	0·821 0247	45
16	·567 3648	·688 9955	·451 3883	·823 4666	·570 9524	·695 4496	·437 9187	·820 9832	44
17	·567 4247	·689 1027	·451 1624	·823 4253	·571 0121	·695 5575	·437 6957	·820 9416	43
18	·567 4845	·689 2100	·450 9366	·823 3841	·571 0718	·695 6654	·437 4727	·820 9001	42
19	·567 5444	·689 3173	·450 7108	·823 3428	·571 1315	·695 7733	·437 2497	·820 8586	41
20	0·567 6043	0·689 4246	1·450 4850	0·823 3015	0·571 1912	0·695 8813	1·437 0268	0·820 8170	40
21	·567 6642	·689 5318	·450 2593	·823 2602	·571 2509	·695 9892	·436 8039	·820 7755	39
22	·567 7240	·689 6392	·450 0337	·823 2189	·571 3106	·696 0972	·436 5811	·820 7340	38
23	·567 7839	·689 7465	·449 8081	·823 1777	·571 3703	·696 2051	·436 3583	·820 6924	37
24	·567 8437	·689 8538	·449 5825	·823 1364	·571 4299	·696 3131	·436 1356	·820 6509	36
25	0·567 9036	0·689 9611	1·449 3570	0·823 0951	0·571 4896	0·696 4211	1·435 9129	0·820 6093	35
26	·567 9635	·690 0685	·449 1316	·823 0538	·571 5493	·696 5291	·435 6902	·820 5677	34
27	·568 0233	·690 1758	·448 9061	·823 0125	·571 6090	·696 6371	·435 4676	·820 5262	33
28	·568 0832	·690 2832	·448 6808	·822 9712	·571 6686	·696 7451	·435 2451	·820 4846	32
29	·568 1430	·690 3906	·448 4555	·822 9298	·571 7283	·696 8531	·435 0226	·820 4430	31
30	0·568 2029	0·690 4980	1·448 2302	0·822 8885	0·571 7880	0·696 9612	1·434 8001	0·820 4014	30
31	·568 2627	·690 6054	·448 0050	·822 8472	·571 8476	·697 0692	·434 5777	·820 3599	29
32	·568 3225	·690 7128	·447 7798	·822 8059	·571 9073	·697 1773	·434 3554	·820 3183	28
33	·568 3824	·690 8202	·447 5547	·822 7645	·571 9669	·697 2854	·434 1331	·820 2767	27
34	·568 4422	·690 9276	·447 3296	·822 7232	·572 0266	·697 3935	·433 9108	·820 2351	26
35	0·568 5020	0·691 0351	1·447 1045	0·822 6819	0·572 0862	0·697 5016	1·433 6886	0·820 1935	25
36	·568 5619	·691 1425	·446 8796	·822 6405	·572 1459	·697 6097	·433 4664	·820 1519	24
37	·568 6217	·691 2500	·446 6546	·822 5992	·572 2055	·697 7178	·433 2443	·820 1103	23
38	·568 6815	·691 3575	·446 4297	·822 5578	·572 2652	·697 8259	·433 0222	·820 0687	22
39	·568 7413	·691 4650	·446 2049	·822 5165	·572 3248	·697 9341	·432 8001	·820 0270	21
40	0·568 8011	0·691 5725	1·445 9801	0·822 4751	0·572 3844	0·698 0422	1·432 5781	0·819 9854	20
41	·568 8609	·691 6800	·445 7553	·822 4337	·572 4441	·698 1504	·432 3562	·819 9438	19
42	·568 9207	·691 7875	·445 5306	·822 3924	·572 5037	·698 2585	·432 1343	·819 9022	18
43	·568 9805	·691 8950	·445 3060	822 3510	·572 5633	·698 3667	·431 9124	·819 8605	17
44	·569 0403	·692 0026	·445 0814	·822 3096	·572 6229	·698 4749	·431 6906	·819 8189	16
45	0·569 1001	0·692 1101	1·444 8568	0·822 2682	0·572 6825	0·698 5831	1·431 4689	0·819 7772	15
46	·569 1599	·692 2177	·444 6323	·822 2268	·572 7422	·698 6913	·431 2472	·819 7356	14
47	·569 2197	·692 3252	·444 4078	·822 1854	·572 8018	·698 7996	·431 0255	·819 6939	13
48	·569 2795	·692 4328	·444 1834	·822 1440	·572 8614	·698 9078	·430 8039	·819 6523	12
49	·569 3393	·692 5404	·443 9590	·822 1026	·572 9210	·699 0161	·430 5823	·819 6106	11
50	0·569 3991	0·692 6480	1·443 7347	0·822 0612	0·572 9806	0·699 1243	1·430 3608	0·819 5689	10
51	·569 4589	·692 7556	·443 5104	·822 0198	·573 0402	·699 2326	·430 1393	·819 5273	09
52	·569 5187	·692 8633	·443 2862	·821 9784	·573 0998	·699 3409	·429 9178	·819 4856	08
53	·569 5784	·692 9709	·443 0620	·821 9370	·573 1594	·699 4492	·429 6965	·819 4439	07
54	·569 6382	·693 0786	·442 8379	·821 8956	·573 2190	·699 5575	·429 4751	·819 4022	06
55	0·569 6980	0·693 1862	1·442 6138	0·821 8541	0·573 2785	0·699 6658	1·429 2538	0·819 3605	05
56	·569 7577	·693 2939	·442 3897	·821 8127	·573 3381	·699 7741	·429 0326	·819 3189	04
57	·569 8175	·693 4016	·442 1657	·821 7713	·573 3977	·699 8825	·428 8114	·819 2772	03
58	·569 8773	·693 5093	·441 9418	·821 7298	·573 4573	·699 9908	·428 5902	·819 2355	02
59	·569 9370	·693 6170	·441 7179	·821 6884	·573 5169	·700 0992	·428 3691	·819 1938	01
60	0·569 9968	0·693 7247	1·441 4940	0·821 6469	0·573 5764	0·700 2075	1·428 1480	0·819 1520	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	597–600	1077–1070	2239–2266	415–412	595–598	1084–1077	2211–2238	418–414	d

$3^h\ 41^m$ $3^h\ 40^m$

2^h 20^m 2^h 21^m

d	596–594	1084–1091	2210–2183	417–420	594–592	1090–1098	2183–2157	419–423	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·573 5764	0·700 2075	1·428 1480	0·819 1520	0·577 1452	0·706 7301	1·414 9673	0·816 6416	60
01	·573 6360	·700 3159	·427 9270	·819 1103	·577 2046	·706 8392	·414 7490	·816 5996	59
02	·573 6956	·700 4243	·427 7060	·819 0686	·577 2640	·706 9482	·414 5307	·816 5576	58
03	·573 7551	·700 5327	·427 4851	·819 0269	·577 3233	·707 0573	·414 3125	·816 5156	57
04	·573 8147	·700 6411	·427 2642	·818 9852	·577 3827	·707 1664	·414 0943	·816 4736	56
05	0·573 8743	0·700 7496	1·427 0433	0·818 9434	0·577 4421	0·707 2755	1·413 8762	0·816 4316	55
06	·573 9338	·700 8580	·426 8226	·818 9017	·577 5015	·707 3846	·413 6582	·816 3897	54
07	·573 9934	·700 9664	·426 6018	·818 8600	·577 5608	·707 4937	·413 4401	·816 3477	53
08	·574 0529	·701 0749	·426 3811	·818 8182	·577 6202	·707 6028	·413 2221	·816 3056	52
09	·574 1124	·701 1834	·426 1604	·818 7765	·577 6796	·707 7120	·413 0042	·816 2636	51
10	0·574 1720	0·701 2919	1·425 9398	0·818 7347	0·577 7389	0·707 8211	1·412 7863	0·816 2216	50
11	·574 2315	·701 4004	·425 7193	·818 6930	·577 7983	·707 9303	·412 5685	·816 1796	49
12	·574 2911	·701 5089	·425 4988	·818 6512	·577 8576	·708 0395	·412 3506	·816 1376	48
13	·574 3506	·701 6174	·425 2783	·818 6094	·577 9170	·708 1487	·412 1329	·816 0956	47
14	·574 4101	·701 7259	·425 0578	·818 5677	·577 9763	·708 2578	·411 9152	·816 0535	46
15	0·574 4697	0·701 8344	1·424 8375	0·818 5259	0·578 0357	0·708 3671	1·411 6975	0·816 0115	45
16	·574 5292	·701 9430	·424 6171	·818 4841	·578 0950	·708 4763	·411 4799	·815 9695	44
17	·574 5887	·702 0515	·424 3968	·818 4423	·578 1543	·708 5855	·411 2623	·815 9274	43
18	·574 6482	·702 1601	·424 1766	·818 4005	·578 2137	·708 6947	·411 0448	·815 8854	42
19	·574 7077	·702 2687	·423 9564	·818 3587	·578 2730	·708 8040	·410 8273	·815 8433	41
20	0·574 7672	0·702 3773	1·423 7362	0·818 3169	0·578 3323	0·708 9133	1·410 6098	0·815 8013	40
21	·574 8267	·702 4859	·423 5161	·818 2751	·578 3917	·709 0225	·410 3924	·815 7592	39
22	·574 8863	·702 5945	·423 2961	·818 2333	·578 4510	·709 1318	·410 1750	·815 7171	38
23	·574 9458	·702 7031	·423 0760	·818 1915	·578 5103	·709 2411	·409 9577	·815 6751	37
24	·575 0053	·702 8118	·422 8561	·818 1497	·578 5696	·709 3504	·409 7405	·815 6330	36
25	0·575 0647	0·702 9204	1·422 6362	0·818 1079	0·578 6289	0·709 4597	1·409 5232	0·815 5909	35
26	·575 1242	·703 0291	·422 4163	·818 0661	·578 6882	·709 5691	·409 3061	·815 5488	34
27	·575 1837	·703 1377	·422 1964	·818 0243	·578 7475	·709 6784	·409 0889	·815 5068	33
28	·575 2432	·703 2464	·421 9766	·817 9824	·578 8069	·709 7878	·408 8718	·815 4647	32
29	·575 3027	·703 3551	·421 7569	·817 9406	·578 8662	·709 8971	·408 6548	·815 4226	31
30	0·575 3622	0·703 4638	1·421 5372	0·817 8987	0·578 9255	0·710 0065	1·408 4378	0·815 3805	30
31	·575 4217	·703 5725	·421 3175	·817 8569	·578 9847	·710 1159	·408 2208	·815 3384	29
32	·575 4811	·703 6813	·421 0979	·817 8151	·579 0440	·710 2253	·408 0039	·815 2963	28
33	·575 5406	·703 7900	·420 8784	·817 7732	·579 1033	·710 3347	·407 7870	·815 2542	27
34	·575 6001	·703 8988	·420 6589	·817 7313	·579 1626	·710 4441	·407 5702	·815 2120	26
35	0·575 6595	0·704 0075	1·420 4394	0·817 6895	0·579 2219	0·710 5536	1·407 3534	0·815 1699	25
36	·575 7190	·704 1163	·420 2200	·817 6476	·579 2812	·710 6630	·407 1367	·815 1278	24
37	·575 7785	·704 2251	·420 0006	·817 6057	·579 3404	·710 7725	·406 9200	·815 0857	23
38	·575 8379	·704 3339	·419 7812	·817 5639	·579 3997	·710 8819	·406 7034	·815 0435	22
39	·575 8974	·704 4427	·419 5620	·817 5220	·579 4590	·710 9914	·406 4868	·815 0014	21
40	0·575 9568	0·704 5515	1·419 3427	0·817 4801	0·579 5183	0·711 1009	1·406 2702	0·814 9593	20
41	·576 0163	·704 6603	·419 1235	·817 4382	·579 5775	·711 2104	·406 0537	·814 9171	19
42	·576 0757	·704 7691	·418 9043	·817 3963	·579 6368	·711 3199	·405 8372	·814 8750	18
43	·576 1352	·704 8780	·418 6852	·817 3544	·579 6960	·711 4294	·405 6208	·814 8328	17
44	·576 1946	·704 9869	·418 4662	·817 3125	·579 7553	·711 5390	·405 4044	·814 7906	16
45	0·576 2540	0·705 0957	1·418 2472	0·817 2706	0·579 8145	0·711 6485	1·405 1881	0·814 7485	15
46	·576 3135	·705 2046	·418 0282	·817 2287	·579 8738	·711 7581	·404 9718	·814 7063	14
47	·576 3729	·705 3135	·417 8093	·817 1868	·579 9330	·711 8676	·404 7555	·814 6641	13
48	·576 4323	·705 4224	·417 5904	·817 1449	·579 9923	·711 9772	·404 5393	·814 6220	12
49	·576 4917	·705 5313	·417 3715	·817 1030	·580 0515	·712 0868	·404 3232	·814 5798	11
50	0·576 5512	0·705 6402	1·417 1527	0·817 0611	0·580 1108	0·712 1964	1·404 1070	0·814 5376	10
51	·576 6106	·705 7492	·416 9340	·817 0191	·580 1700	·712 3060	·403 8910	·814 4954	09
52	·576 6700	·705 8581	·416 7153	·816 9772	·580 2292	·712 4157	·403 6749	·814 4532	08
53	·576 7294	·705 9671	·416 4966	·816 9352	·580 2885	·712 5253	·403 4590	·814 4110	07
54	·576 7888	·706 0761	·416 2780	·816 8933	·580 3477	·712 6349	·403 2430	·814 3688	06
55	0·576 8482	0·706 1850	1·416 0594	0·816 8514	0·580 4069	0·712 7446	1·403 0271	0·814 3266	05
56	·576 9076	·706 2940	·415 8409	·816 8094	·580 4661	·712 8543	·402 8113	·814 2844	04
57	·576 9670	·706 4030	·415 6224	·816 7674	·580 5253	·712 9640	·402 5955	·814 2422	03
58	·577 0264	·706 5121	·415 4040	·816 7255	·580 5845	·713 0736	·402 3797	·814 2000	02
59	·577 0858	·706 6211	·415 1856	·816 6835	·580 6438	·713 1834	·402 1640	·814 1577	01
60	0·577 1452	0·706 7301	1·414 9673	0·816 6416	0·580 7030	0·713 2931	1·401 9483	0·814 1155	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	594–596	1091–1084	2183–2210	420–417	592–594	1098–1090	2157–2183	423–419	d

3^h 39^m 3^h 38^m

$2^{h}\ 22^{m}$ | $2^{h}\ 23^{m}$

d	592–590	1097–1104	2156–2131	422–425	590–588	1104–1111	2130–2105	425–428	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·580 7030	0·713 2931	1·401 9483	0·814 1155	0·584 2497	0·719 8970	1·389 0876	0·811 5740	60
01	·580 7622	·713 4028	·401 7327	·814 0733	·584 3087	·720 0074	·388 8746	·811 5315	59
02	·580 8214	·713 5125	·401 5171	·814 0310	·584 3677	·720 1178	·388 6616	·811 4890	58
03	·580 8806	·713 6223	·401 3015	·813 9888	·584 4267	·720 2283	·388 4487	·811 4465	57
04	·580 9397	·713 7320	·401 0860	·813 9466	·584 4857	·720 3387	·388 2358	·811 4040	56
05	0·580 9989	0·713 8418	1·400 8706	0·813 9043	0·584 5447	0·720 4492	1·388 0229	0·811 3615	55
06	·581 0581	·713 9516	·400 6552	·813 8621	·584 6037	·720 5597	·387 8101	·811 3190	54
07	·581 1173	·714 0614	·400 4398	·813 8198	·584 6627	·720 6701	·387 5974	·811 2765	53
08	·581 1765	·714 1712	·400 2245	·813 7775	·584 7217	·720 7806	·387 3847	·811 2339	52
09	·581 2357	·714 2810	·400 0092	·813 7353	·584 7807	·720 8912	·387 1720	·811 1914	51
10	0·581 2948	0·714 3909	1·399 7939	0·813 6930	0·584 8397	0·721 0017	1·386 9593	0·811 1489	50
11	·581 3540	·714 5007	·399 5788	·813 6507	·584 8987	·721 1122	·386 7467	·811 1064	49
12	·581 4132	·714 6106	·399 3636	·813 6084	·584 9577	·721 2227	·386 5342	·811 0638	48
13	·581 4724	·714 7204	·399 1485	·813 5662	·585 0167	·721 3333	·386 3217	·811 0213	47
14	·581 5315	·714 8303	·398 9334	·813 5239	·585 0756	·721 4439	·386 1092	·810 9787	46
15	0·581 5907	0·714 9402	1·398 7184	0·813 4816	0·585 1346	0·721 5544	1·385 8968	0·810 9362	45
16	·581 6498	·715 0501	·398 5034	·813 4393	·585 1936	·721 6650	·385 6844	·810 8936	44
17	·581 7090	·715 1600	·398 2885	·813 3970	·585 2525	·721 7756	·385 4721	·810 8511	43
18	·581 7681	·715 2699	·398 0736	·813 3547	·585 3115	·721 8863	·385 2598	·810 8085	42
19	·581 8273	·715 3798	·397 8588	·813 3124	·585 3705	·721 9969	·385 0475	·810 7659	41
20	0·581 8864	0·715 4898	1·397 6440	0·813 2701	0·585 4294	0·722 1075	1·384 8353	0·810 7234	40
21	·581 9456	·715 5997	·397 4292	·813 2277	·585 4884	·722 2182	·384 6232	·810 6808	39
22	·582 0047	·715 7097	·397 2145	·813 1854	·585 5473	·722 3288	·384 4111	·810 6382	38
23	·582 0638	·715 8197	·396 9998	·813 1431	·585 6063	·722 4395	·384 1990	·810 5956	37
24	·582 1230	·715 9297	·396 7852	·813 1008	·585 6652	·722 5502	·383 9869	·810 5530	36
25	0·582 1821	0·716 0397	1·396 5706	0·813 0584	0·585 7242	0·722 6609	1·383 7749	0·810 5104	35
26	·582 2412	·716 1497	·396 3561	·813 0161	·585 7831	·722 7716	·383 5630	·810 4678	34
27	·582 3003	·716 2597	·396 1416	·812 9737	·585 8421	·722 8823	·383 3511	·810 4252	33
28	·582 3595	·716 3698	·395 9272	·812 9314	·585 9010	·722 9930	·383 1392	·810 3826	32
29	·582 4186	·716 4798	·395 7127	·812 8890	·585 9599	·723 1038	·382 9274	·810 3400	31
30	0·582 4777	0·716 5899	1·395 4984	0·812 8467	0·586 0189	0·723 2145	1·382 7156	0·810 2974	30
31	·582 5368	·716 6999	·395 2841	·812 8043	·586 0778	·723 3253	·382 5039	·810 2548	29
32	·582 5959	·716 8100	·395 0698	·812 7620	·586 1367	·723 4361	·382 2922	·810 2122	28
33	·582 6550	·716 9201	·394 8556	·812 7196	·586 1956	·723 5468	·382 0805	·810 1695	27
34	·582 7141	·717 0302	·394 6414	·812 6772	·586 2545	·723 6576	·381 8689	·810 1269	26
35	0·582 7732	0·717 1403	1·394 4272	0·812 6348	0·586 3134	0·723 7685	1·381 6573	0·810 0843	25
36	·582 8323	·717 2505	·394 2131	·812 5925	·586 3724	·723 8793	·381 4458	·810 0416	24
37	·582 8914	·717 3606	·393 9991	·812 5501	·586 4313	·723 9901	·381 2343	·809 9990	23
38	·582 9505	·717 4708	·393 7850	·812 5077	·586 4902	·724 1010	·381 0229	·809 9563	22
39	·583 0096	·717 5809	·393 5711	·812 4653	·586 5491	·724 2118	·380 8115	·809 9137	21
40	0·583 0687	0·717 6911	1·393 3571	0·812 4229	0·586 6080	0·724 3227	1·380 6001	0·809 8710	20
41	·583 1277	·717 8013	·393 1432	·812 3805	·586 6669	·724 4336	·380 3888	·809 8284	19
42	·583 1868	·717 9115	·392 9294	·812 3381	·586 7257	·724 5445	·380 1776	·809 7857	18
43	·583 2459	·718 0217	·392 7156	·812 2957	·586 7846	·724 6554	·379 9663	·809 7430	17
44	·583 3050	·718 1319	·392 5019	·812 2532	·586 8435	·724 7663	·379 7551	·809 7004	16
45	0·583 3640	0·718 2421	1·392 2881	0·812 2108	0·586 9024	0·724 8772	1·379 5440	0·809 6577	15
46	·583 4231	·718 3524	·392 0745	·812 1684	·586 9613	·724 9881	·379 3329	·809 6150	14
47	·583 4822	·718 4626	·391 8608	·812 1260	·587 0202	·725 0991	·379 1218	·809 5723	13
48	·583 5412	·718 5729	·391 6473	·812 0835	·587 0790	·725 2101	·378 9108	·809 5296	12
49	·583 6003	·718 6832	·391 4337	·812 0411	·587 1379	·725 3210	·378 6998	·809 4869	11
50	0·583 6593	0·718 7935	1·391 2202	0·811 9986	0·587 1968	0·725 4320	1·378 4889	0·809 4442	10
51	·583 7184	·718 9038	·391 0068	·811 9562	·587 2556	·725 5430	·378 2780	·809 4015	09
52	·583 7774	·719 0141	·390 7934	·811 9137	·587 3145	·725 6540	·378 0672	·809 3588	08
53	·583 8365	·719 1244	·390 5800	·811 8713	·587 3733	·725 7650	·377 8564	·809 3161	07
54	·583 8955	·719 2347	·390 3667	·811 8288	·587 4322	·725 8761	·377 6456	·809 2734	06
55	0·583 9545	0·719 3451	1·390 1534	0·811 7864	0·587 4910	0·725 9871	1·377 4349	0·809 2307	05
56	·584 0136	·719 4554	·389 9401	·811 7439	·587 5499	·726 0982	·377 2242	·809 1879	04
57	·584 0726	·719 5658	·389 7270	·811 7014	·587 6087	·726 2093	·377 0136	·809 1452	03
58	·584 1316	·719 6762	·389 5138	·811 6589	·587 6676	·726 3203	·376 8030	·809 1025	02
59	·584 1906	·719 7866	·389 3007	·811 6165	·587 7264	·726 4314	·376 5924	·809 0597	01
60	0·584 2497	0·719 8970	1·389 0876	0·811 5740	0·587 7853	0·726 5425	1·376 3819	0·809 0170	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	590–592	1104–1097	2131–2156	425–422	588–590	1111–1104	2105–2130	428–425	d

$3^{h}\ 37^{m}$ | $3^{h}\ 36^{m}$

$2^{h}\ 24^{m}$ $2^{h}\ 25^{m}$

d	589–586	1111–1118	2105–2080	427–430	587–584	1118–1126	2080–2056	430–433	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·587 7853	0·726 5425	1·376 3819	0·809 0170	0·591 3096	0·733 2303	1·363 8279	0·806 4446	60
01	·587 8441	·726 6536	·376 1715	·808 9742	·591 3683	·733 3422	·363 6199	·806 4016	59
02	·587 9029	·726 7648	·375 9610	·808 9315	·591 4269	·733 4540	·363 4120	·806 3586	58
03	·587 9617	·726 8759	·375 7506	·808 8887	·591 4856	·733 5658	·363 2041	·806 3156	57
04	·588 0206	·726 9871	·375 5403	·808 8460	·591 5442	·733 6777	·362 9963	·806 2726	56
05	0·588 0794	0·727 0982	1·375 3300	0·808 8032	0·591 6028	0·733 7896	1·362 7885	0·806 2295	55
06	·588 1382	·727 2094	·375 1197	·808 7604	·591 6615	·733 9015	·362 5807	·806 1865	54
07	·588 1970	·727 3206	·374 9095	·808 7177	·591 7201	·734 0134	·362 3730	·806 1435	53
08	·588 2558	·727 4318	·374 6994	·808 6749	·591 7787	·734 1253	·362 1653	·806 1005	52
09	·588 3146	·727 5430	·374 4892	·808 6321	·591 8373	·734 2372	·361 9577	·806 0574	51
10	0·588 3734	0·727 6542	1·374 2791	0·808 5893	0·591 8960	0·734 3491	1·361 7501	0·806 0144	50
11	·588 4322	·727 7654	·374 0691	·808 5465	·591 9546	·734 4611	·361 5425	·805 9713	49
12	·588 4910	·727 8767	·373 8591	·808 5037	·592 0132	·734 5730	·361 3350	·805 9283	48
13	·588 5498	·727 9879	·373 6491	·808 4609	·592 0718	·734 6850	·361 1276	·805 8852	47
14	·588 6086	·728 0992	·373 4392	·808 4181	·592 1304	·734 7970	·360 9201	·805 8422	46
15	0·588 6674	0·728 2105	1·373 2293	0·808 3753	0·592 1890	0·734 9090	1·360 7127	0·805 7991	45
16	·588 7262	·728 3218	·373 0195	·808 3325	·592 2476	·735 0210	·360 5054	·805 7560	44
17	·588 7850	·728 4331	·372 8097	·808 2897	·592 3062	·735 1330	·360 2981	·805 7130	43
18	·588 8437	·728 5444	·372 5999	·808 2469	·592 3648	·735 2450	·360 0908	·805 6699	42
19	·588 9025	·728 6557	·372 3902	·808 2041	·592 4234	·735 3571	·359 8836	·805 6268	41
20	0·588 9613	0·728 7671	1·372 1806	0·808 1612	0·592 4819	0·735 4691	1·359 6764	0·805 5837	40
21	·589 0201	·728 8784	·371 9709	·808 1184	·592 5405	·735 5812	·359 4693	·805 5406	39
22	·589 0788	·728 9898	·371 7613	·808 0756	·592 5991	·735 6933	·359 2622	·805 4975	38
23	·589 1376	·729 1012	·371 5518	·808 0327	·592 6577	·735 8053	·359 0551	·805 4544	37
24	·589 1964	·729 2125	·371 3423	·807 9899	·592 7163	·735 9174	·358 8481	·805 4113	36
25	0·589 2551	0·729 3239	1·371 1328	0·807 9470	0·592 7748	0·736 0296	1·358 6411	0·805 3682	35
26	·589 3139	·729 4354	·370 9234	·807 9042	·592 8334	·736 1417	·358 4342	·805 3251	34
27	·589 3726	·729 5468	·370 7140	·807 8613	·592 8920	·736 2538	·358 2273	·805 2820	33
28	·589 4314	·729 6582	·370 5047	·807 8185	·592 9505	·736 3660	·358 0204	·805 2389	32
29	·589 4901	·729 7697	·370 2954	·807 7756	·593 0091	·736 4781	·357 8136	·805 1958	31
30	0·589 5489	0·729 8811	1·370 0862	0·807 7327	0·593 0676	0·736 5903	1·357 6068	0·805 1526	30
31	·589 6076	·729 9926	·369 8769	·807 6898	·593 1262	·736 7025	·357 4001	·805 1095	29
32	·589 6663	·730 1041	·369 6678	·807 6470	·593 1847	·736 8147	·357 1934	·805 0664	28
33	·589 7251	·730 2155	·369 4586	·807 6041	·593 2433	·736 9269	·356 9867	·805 0232	27
34	·589 7838	·730 3271	·369 2496	·807 5612	·593 3018	·737 0391	·356 7801	·804 9801	26
35	0·589 8425	0·730 4386	1·369 0405	0·807 5183	0·593 3604	0·737 1513	1·356 5735	0·804 9369	25
36	·589 9012	·730 5501	·368 8315	·807 4754	·593 4189	·737 2636	·356 3670	·804 8938	24
37	·589 9600	·730 6616	·368 6226	·807 4325	·593 4774	·737 3758	·356 1605	·804 8506	23
38	·590 0187	·730 7732	·368 4136	·807 3896	·593 5359	·737 4881	·355 9541	·804 8075	22
39	·590 0774	·730 8848	·368 2048	·807 3467	·593 5945	·737 6004	·355 7477	·804 7643	21
40	0·590 1361	0·730 9963	1·367 9959	0·807 3038	0·593 6530	0·737 7127	1·355 5413	0·804 7211	20
41	·590 1948	·731 1079	·367 7871	·807 2609	·593 7115	·737 8250	·355 3350	·804 6780	19
42	·590 2535	·731 2195	·367 5784	·807 2179	·593 7700	·737 9373	·355 1287	·804 6348	18
43	·590 3122	·731 3311	·367 3697	·807 1750	·593 8285	·738 0496	·354 9224	·804 5916	17
44	·590 3709	·731 4428	·367 1610	·807 1321	·593 8871	·738 1620	·354 7162	·804 5484	16
45	0·590 4296	0·731 5544	1·366 9524	0·807 0891	0·593 9456	0·738 2743	1·354 5101	0·804 5052	15
46	·590 4883	·731 6660	·366 7438	·807 0462	·594 0041	·738 3867	·354 3039	·804 4620	14
47	·590 5470	·731 7777	·366 5352	·807 0033	·594 0626	·738 4991	·354 0978	·804 4188	13
48	·590 6057	·731 8894	·366 3267	·806 9603	·594 1211	·738 6115	·353 8918	·804 3756	12
49	·590 6643	·732 0010	·366 1183	·806 9174	·594 1796	·738 7239	·353 6858	·804 3324	11
50	0·590 7230	0·732 1127	1·365 9098	0·806 8744	0·594 2380	0·738 8363	1·353 4798	0·804 2892	10
51	·590 7817	·732 2244	·365 7015	·806 8314	·594 2965	·738 9487	·353 2739	·804 2460	09
52	·590 8404	·732 3362	·365 4931	·806 7885	·594 3550	·739 0611	·353 0680	·804 2028	08
53	·590 8990	·732 4479	·365 2848	·806 7455	·594 4135	·739 1736	·352 8622	·804 1596	07
54	·590 9577	·732 5596	·365 0766	·806 7025	·594 4720	·739 2861	·352 6564	·804 1163	06
55	0·591 0164	0·732 6714	1·364 8684	0·806 6596	0·594 5305	0·739 3985	1·352 4506	0·804 0731	05
56	·591 0750	·732 7832	·364 6602	·806 6166	·594 5889	·739 5110	·352 2449	·804 0299	04
57	·591 1337	·732 8949	·364 4521	·806 5736	·594 6474	·739 6235	·352 0392	·803 9866	03
58	·591 1923	·733 0067	·364 2440	·806 5306	·594 7059	·739 7360	·351 8336	·803 9434	02
59	·591 2510	·733 1185	·364 0359	·806 4876	·594 7643	·739 8485	·351 6280	·803 9001	01
60	0·591 3096	0·733 2303	1·363 8279	0·806 4446	0·594 8228	0·739 9611	1·351 4224	0·803 8569	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	586–589	1118–1111	2080–2105	430–427	584–587	1126–1118	2056–2080	433–430	d

$3^{h}\ 35^{m}$ $3^{h}\ 34^{m}$

$2^h\ 26^m$ $2^h\ 27^m$

d	585–582	1125–1133	2055–2032	432–435	583–580	1133–1141	2031–2008	435–438	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·594 8228	0·739 9611	1·351 4224	0·803 8569	0·598 3246	0·746 7354	1·339 1624	0·801 2538	60
01	·594 8812	·740 0736	·351 2169	·803 8136	·598 3829	·746 8487	·338 9593	·801 2103	59
02	·594 9397	·740 1862	·351 0114	·803 7703	·598 4411	·746 9620	·338 7562	·801 1668	58
03	·594 9981	·740 2988	·350 8060	·803 7271	·598 4994	·747 0753	·338 5532	·801 1233	57
04	·595 0566	·740 4113	·350 6006	·803 6838	·598 5577	·747 1886	·338 3502	·801 0797	56
05	0·595 1150	0·740 5239	1·350 3953	0·803 6405	0·598 6159	0·747 3019	1·338 1472	0·801 0362	55
06	·595 1735	·740 6365	·350 1899	·803 5972	·598 6742	·747 4153	·337 9443	·800 9927	54
07	·595 2319	·740 7492	·349 9847	·803 5540	·598 7324	·747 5286	·337 7414	·800 9491	53
08	·595 2904	·740 8618	·349 7794	·803 5107	·598 7906	·747 6420	·337 5386	·800 9056	52
09	·595 3488	·740 9744	·349 5742	·803 4674	·598 8489	·747 7554	·337 3358	·800 8620	51
10	0·595 4072	0·741 0871	1·349 3691	0·803 4241	0·598 9071	0·747 8688	1·337 1330	0·800 8185	50
11	·595 4656	·741 1998	·349 1640	·803 3808	·598 9654	·747 9822	·336 9303	·800 7749	49
12	·595 5241	·741 3124	·348 9589	·803 3375	·599 0236	·748 0956	·336 7276	·800 7314	48
13	·595 5825	·741 4251	·348 7539	·803 2942	·599 0818	·748 2090	·336 5249	·800 6878	47
14	·595 6409	·741 5378	·348 5489	·803 2508	·599 1401	·748 3224	·336 3223	·800 6442	46
15	0·595 6993	0·741 6505	1·348 3439	0·803 2075	0·599 1983	0·748 4359	1·336 1198	0·800 6007	45
16	·595 7577	·741 7633	·348 1390	·803 1642	·599 2565	·748 5494	·335 9172	·800 5571	44
17	·595 8161	·741 8760	·347 9341	·803 1209	·599 3147	·748 6628	·335 7148	·800 5135	43
18	·595 8745	·741 9888	·347 7293	·803 0776	·599 3729	·748 7763	·335 5123	·800 4699	42
19	·595 9329	·742 1015	·347 5245	·803 0342	·599 4311	·748 8898	·335 3099	·800 4263	41
20	0·595 9913	0·742 2143	1·347 3198	0·802 9909	0·599 4893	0·749 0033	1·335 1075	0·800 3827	40
21	·596 0497	·742 3271	·347 1150	·802 9475	·599 5475	·749 1169	·334 9052	·800 3391	39
22	·596 1081	·742 4399	·346 9104	·802 9042	·599 6057	·749 2304	·334 7029	·800 2955	38
23	·596 1665	·742 5527	·346 7057	·802 8608	·599 6639	·749 3440	·334 5007	·800 2519	37
24	·596 2249	·742 6655	·346 5011	·802 8175	·599 7221	·749 4575	·334 2984	·800 2083	36
25	0·596 2833	0·742 7784	1·346 2966	0·802 7741	0·599 7803	0·749 5711	1·334 0963	0·800 1647	35
26	·596 3416	·742 8912	·346 0921	·802 7307	·599 8385	·749 6847	·333 8941	·800 1211	34
27	·596 4000	·743 0041	·345 8876	·802 6874	·599 8967	·749 7983	·333 6920	·800 0775	33
28	·596 4584	·743 1170	·345 6832	·802 6440	·599 9549	·749 9119	·333 4900	·800 0338	32
29	·596 5167	·743 2299	·345 4788	·802 6006	·600 0131	·750 0255	·333 2880	·799 9902	31
30	0·596 5751	0·743 3428	1·345 2744	0·802 5572	0·600 0712	0·750 1392	1·333 0860	0·799 9466	30
31	·596 6335	·743 4557	·345 0701	·802 5139	·600 1294	·750 2528	·332 8841	·799 9029	29
32	·596 6918	·743 5686	·344 8658	·802 4705	·600 1876	·750 3665	·332 6822	·799 8593	28
33	·596 7502	·743 6815	·344 6616	·802 4271	·600 2457	·750 4801	·332 4803	·799 8156	27
34	·596 8085	·743 7945	·344 4574	·802 3837	·600 3039	·750 5938	·332 2785	·799 7720	26
35	0·596 8669	0·743 9074	1·344 2533	0·802 3403	0·600 3621	0·750 7075	1·332 0767	0·799 7283	25
36	·596 9252	·744 0204	·344 0492	·802 2969	·600 4202	·750 8212	·331 8750	·799 6847	24
37	·596 9836	·744 1334	·343 8451	·802 2535	·600 4784	·750 9350	·331 6732	·799 6410	23
38	·597 0419	·744 2464	·343 6411	·802 2100	·600 5365	·751 0487	·331 4716	·799 5973	22
39	·597 1003	·744 3594	·343 4371	·802 1666	·600 5947	·751 1624	·331 2700	·799 5536	21
40	0·597 1586	0·744 4724	1·343 2331	0·802 1232	0·600 6528	0·751 2762	1·331 0684	0·799 5100	20
41	·597 2169	·744 5855	·343 0292	·802 0798	·600 7110	·751 3900	·330 8668	·799 4663	19
42	·597 2752	·744 6985	·342 8253	·802 0363	·600 7691	·751 5038	·330 6653	·799 4226	18
43	·597 3336	·744 8116	·342 6215	·801 9929	·600 8272	·751 6176	·330 4638	·799 3789	17
44	·597 3919	·744 9246	·342 4177	·801 9495	·600 8854	·751 7314	·330 2624	·799 3352	16
45	0·597 4502	0·745 0377	1·342 2139	0·801 9060	0·600 9435	0·751 8452	1·330 0610	0·799 2915	15
46	·597 5085	·745 1508	·342 0102	·801 8626	·601 0016	·751 9590	·329 8597	·799 2478	14
47	·597 5668	·745 2639	·341 8066	·801 8191	·601 0597	·752 0729	·329 6584	·799 2041	13
48	·597 6251	·745 3770	·341 6029	·801 7756	·601 1179	·752 1867	·329 4571	·799 1604	12
49	·597 6835	·745 4902	·341 3993	·801 7322	·601 1760	·752 3006	·329 2558	·799 1167	11
50	0·597 7418	0·745 6033	1·341 1958	0·801 6887	0·601 2341	0·752 4145	1·329 0547	0·799 0730	10
51	·597 8001	·745 7165	·340 9923	·801 6452	·601 2922	·752 5284	·328 8535	·799 0292	09
52	·597 8583	·745 8296	·340 7888	·801 6018	·601 3503	·752 6423	·328 6524	·798 9855	08
53	·597 9166	·745 9428	·340 5853	·801 5583	·601 4084	·752 7562	·328 4513	·798 9418	07
54	·597 9749	·746 0560	·340 3820	·801 5148	·601 4665	·752 8702	·328 2503	·798 8980	06
55	0·598 0332	0·746 1692	1·340 1786	0·801 4713	0·601 5246	0·752 9841	1·328 0493	0·798 8543	05
56	·598 0915	·746 2824	·339 9753	·801 4278	·601 5827	·753 0981	·327 8483	·798 8105	04
57	·598 1498	·746 3957	·339 7720	·801 3843	·601 6408	·753 2121	·327 6474	·798 7668	03
58	·598 2081	·746 5089	·339 5688	·801 3408	·601 6989	·753 3260	·327 4465	·798 7230	02
59	·598 2663	·746 6222	·339 3656	·801 2973	·601 7569	·753 4400	·327 2456	·798 6793	01
60	0·598 3246	0·746 7354	1·339 1624	0·801 2538	0·601 8150	0·753 5541	1·327 0448	0·798 6355	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	582–585	1133–1125	2032–2055	435–432	580–583	1141–1133	2008–2031	438–435	d

$3^h\ 33^m$ $3^h\ 32^m$

$2^h\ 28^m$ | $2^h\ 29^m$

d	581–579	1140–1148	2008–1985	437–440	579–577	1147–1156	1985–1962	440–443	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·601 8150	0·753 5541	1·327 0448	0·798 6355	0·605 2940	0·760 4177	1·315 0668	0·796 0020	60
01	·601 8731	·753 6681	·326 8441	·798 5917	·605 3519	·760 5324	·314 8683	·795 9580	59
02	·601 9312	·753 7821	·326 6433	·798 5480	·605 4098	·760 6472	·314 6699	·795 9140	58
03	·601 9892	·753 8962	·326 4426	·798 5042	·605 4676	·760 7620	·314 4715	·795 8699	57
04	·602 0473	·754 0102	·326 2420	·798 4604	·605 5255	·760 8769	·314 2731	·795 8259	56
05	0·602 1054	0·754 1243	1·326 0414	0·798 4166	0·605 5834	0·760 9917	1·314 0748	0·795 7819	55
06	·602 1634	·754 2384	·325 8408	·798 3728	·605 6413	·761 1065	·313 8765	·795 7378	54
07	·602 2215	·754 3525	·325 6402	·798 3291	·605 6991	·761 2214	·313 6783	·795 6938	53
08	·602 2795	·754 4666	·325 4397	·798 2853	·605 7570	·761 3363	·313 4801	·795 6497	52
09	·602 3376	·754 5807	·325 2393	·798 2415	·605 8148	·761 4511	·313 2819	·795 6057	51
10	0·602 3956	0·754 6948	1·325 0389	0·798 1976	0·605 8727	0·761 5660	1·313 0838	0·795 5616	50
11	·602 4537	·754 8090	·324 8385	·798 1538	·605 9306	·761 6809	·312 8857	·795 5175	49
12	·602 5117	·754 9232	·324 6381	·798 1100	·605 9884	·761 7959	·312 6876	·795 4735	48
13	·602 5698	·755 0373	·324 4378	·798 0662	·606 0462	·761 9108	·312 4896	·795 4294	47
14	·602 6278	·755 1515	·324 2376	·798 0224	·606 1041	·762 0257	·312 2916	·795 3853	46
15	0·602 6858	0·755 2657	1·324 0373	0·797 9786	0·606 1619	0·762 1407	1·312 0937	0·795 3413	45
16	·602 7439	·755 3799	·323 8371	·797 9347	·606 2198	·762 2557	·311 8958	·795 2972	44
17	·602 8019	·755 4941	·323 6370	·797 8909	·606 2776	·762 3706	·311 6979	·795 2531	43
18	·602 8599	·755 6084	·323 4369	·797 8471	·606 3354	·762 4856	·311 5001	·795 2090	42
19	·602 9179	·755 7226	·323 2368	·797 8032	·606 3933	·762 6006	·311 3023	·795 1649	41
20	0·602 9760	0·755 8369	1·323 0368	0·797 7594	0·606 4511	0·762 7157	1·311 1046	0·795 1208	40
21	·603 0340	·755 9512	·322 8368	·797 7155	·606 5089	·762 8307	·310 9069	·795 0767	39
22	·603 0920	·756 0654	·322 6368	·797 6717	·606 5667	·762 9457	·310 7092	·795 0326	38
23	·603 1500	·756 1797	·322 4369	·797 6278	·606 6245	·763 0608	·310 5116	·794 9885	37
24	·603 2080	·756 2941	·322 2370	·797 5839	·606 6824	·763 1759	·310 3140	·794 9444	36
25	0·603 2660	0·756 4084	1·322 0372	0·797 5401	0·606 7402	0·763 2910	1·310 1164	0·794 9002	35
26	·603 3240	·756 5227	·321 8374	·797 4962	·606 7980	·763 4061	·309 9189	·794 8561	34
27	·603 3820	·756 6371	·321 6376	·797 4523	·606 8558	·763 5212	·309 7214	·794 8120	33
28	·603 4400	·756 7514	·321 4379	·797 4084	·606 9136	·763 6363	·309 5239	·794 7678	32
29	·603 4980	·756 8658	·321 2382	·797 3645	·606 9714	·763 7514	·309 3265	·794 7237	31
30	0·603 5559	0·756 9802	1·321 0385	0·797 3207	0·607 0292	0·763 8666	1·309 1292	0·794 6796	30
31	·603 6139	·757 0946	·320 8389	·797 2768	·607 0869	·763 9817	·308 9318	·794 6354	29
32	·603 6719	·757 2090	·320 6393	·797 2329	·607 1447	·764 0969	·308 7345	·794 5913	28
33	·603 7299	·757 3234	·320 4398	·797 1890	·607 2025	·764 2121	·308 5373	·794 5471	27
34	·603 7878	·757 4379	·320 2403	·797 1451	·607 2603	·764 3273	·308 3400	·794 5030	26
35	0·603 8458	0·757 5523	1·320 0408	0·797 1011	0·607 3181	0·764 4425	1·308 1429	0·794 4588	25
36	·603 9038	·757 6668	·319 8414	·797 0572	·607 3758	·764 5577	·307 9457	·794 4146	24
37	·603 9617	·757 7813	·319 6420	·797 0133	·607 4336	·764 6730	·307 7486	·794 3704	23
38	·604 0197	·757 8957	·319 4427	·796 9694	·607 4914	·764 7882	·307 5515	·794 3263	22
39	·604 0777	·758 0102	·319 2434	·796 9255	·607 5491	·764 9035	·307 3545	·794 2821	21
40	0·604 1356	0·758 1248	1·319 0441	0·796 8815	0·607 6069	0·765 0188	1·307 1575	0·794 2379	20
41	·604 1936	·758 2393	·318 8449	·796 8376	·607 6647	·765 1340	·306 9605	·794 1937	19
42	·604 2515	·758 3538	·318 6457	·796 7936	·607 7224	·765 2494	·306 7636	·794 1495	18
43	·604 3094	·758 4684	·318 4465	·796 7497	·607 7802	·765 3647	·306 5667	·794 1053	17
44	·604 3674	·758 5829	·318 2474	·796 7058	·607 8379	·765 4800	·306 3699	·794 0611	16
45	0·604 4253	0·758 6975	1·318 0484	0·796 6618	0·607 8957	0·765 5953	1·306 1731	0·794 0169	15
46	·604 4833	·758 8121	·317 8493	·796 6178	·607 9534	·765 7107	·305 9763	·793 9727	14
47	·604 5412	·758 9267	·317 6503	·796 5739	·608 0111	·765 8261	·305 7795	·793 9285	13
48	·604 5991	·759 0413	·317 4513	·796 5299	·608 0689	·765 9414	·305 5828	·793 8843	12
49	·604 6570	·759 1559	·317 2524	·796 4859	·608 1266	·766 0568	·305 3862	·793 8401	11
50	0·604 7150	0·759 2706	1·317 0535	0·796 4420	0·608 1843	0·766 1722	1·305 1896	0·793 7958	10
51	·604 7729	·759 3852	·316 8547	·796 3980	·608 2421	·766 2876	·304 9930	·793 7516	09
52	·604 8308	·759 4999	·316 6559	·796 3540	·608 2998	·766 4031	·304 7964	·793 7074	08
53	·604 8887	·759 6146	·316 4571	·796 3100	·608 3575	·766 5185	·304 5999	·793 6631	07
54	·604 9466	·759 7293	·316 2584	·796 2660	·608 4152	·766 6340	·304 4034	·793 6189	06
55	0·605 0045	0·759 8440	1·316 0597	0·796 2220	0·608 4729	0·766 7494	1·304 2070	0·793 5746	05
56	·605 0624	·759 9587	·315 8610	·796 1780	·608 5306	·766 8649	·304 0106	·793 5304	04
57	·605 1203	·760 0734	·315 6624	·796 1340	·608 5883	·766 9804	·303 8142	·793 4861	03
58	·605 1782	·760 1882	·315 4638	·796 0900	·608 6460	·767 0959	·303 6179	·793 4419	02
59	·605 2361	·760 3029	·315 2653	·796 0460	·608 7037	·767 2115	·303 4216	·793 3976	01
60	0·605 2940	0·760 4177	1·315 0668	0·796 0020	0·608 7614	0·767 3270	1·303 2254	0·793 3533	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	579–581	1148–1140	1985–2008	440–437	577–579	1156–1147	1962–1985	443–440	d

$3^h\ 31^m$ | $3^h\ 30^m$

$2^{h}\ 30^{m}$ | $2^{h}\ 31^{m}$

d	577–575	1155–1163	1962–1940	442–445	575–573	1163–1171	1940–1919	445–448	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·608 7614	0·767 3270	1·303 2254	0·793 3533	0·612 2173	0·774 2827	1·291 5179	0·790 6896	60
01	·608 8191	·767 4425	·303 0292	·793 3091	·612 2748	·774 3991	·291 3239	·790 6450	59
02	·608 8768	·767 5581	·302 8330	·793 2648	·612 3323	·774 5154	·291 1299	·790 6005	58
03	·608 9345	·767 6737	·302 6368	·793 2205	·612 3898	·774 6317	·290 9360	·790 5560	57
04	·608 9922	·767 7893	·302 4407	·793 1762	·612 4473	·774 7481	·290 7421	·790 5115	56
05	0·609 0499	0·767 9048	1·302 2447	0·793 1319	0·612 5047	0·774 8645	1·290 5482	0·790 4669	55
06	·609 1075	·768 0205	·302 0486	·793 0876	·612 5622	·774 9809	·290 3544	·790 4224	54
07	·609 1652	·768 1361	·301 8527	·793 0433	·612 6197	·775 0973	·290 1606	·790 3778	53
08	·609 2229	·768 2517	·301 6567	·792 9990	·612 6772	·775 2137	·289 9669	·790 3333	52
09	·609 2805	·768 3674	·301 4608	·792 9547	·612 7347	·775 3301	·289 7732	·790 2887	51
10	0·609 3382	0·768 4830	1·301 2649	0·792 9104	0·612 7921	0·775 4466	1·289 5795	0·790 2441	50
11	·609 3959	·768 5987	·301 0691	·792 8661	·612 8496	·775 5630	·289 3858	·790 1996	49
12	·609 4535	·768 7144	·300 8733	·792 8218	·612 9071	·775 6795	·289 1922	·790 1550	48
13	·609 5112	·768 8301	·300 6775	·792 7775	·612 9645	·775 7960	·288 9987	·790 1104	47
14	·609 5688	·768 9458	·300 4818	·792 7331	·613 0220	·775 9125	·288 8051	·790 0659	46
15	0·609 6265	0·769 0615	1·300 2861	0·792 6888	0·613 0794	0·776 0290	1·288 6116	0·790 0213	45
16	·609 6841	·769 1773	·300 0904	·792 6445	·613 1369	·776 1455	·288 4182	·789 9767	44
17	·609 7418	·769 2930	·299 8948	·792 6001	·613 1943	·776 2621	·288 2247	·789 9321	43
18	·609 7994	·769 4088	·299 6992	·792 5558	·613 2518	·776 3786	·288 0314	·789 8875	42
19	·609 8570	·769 5246	·299 5036	·792 5114	·613 3092	·776 4952	·287 8380	·789 8429	41
20	0·609 9147	0·769 6404	1·299 3081	0·792 4671	0·613 3666	0·776 6118	1·287 6447	0·789 7983	40
21	·609 9723	·769 7562	·299 1127	·792 4227	·613 4241	·776 7283	·287 4514	·789 7537	39
22	·610 0299	·769 8720	·298 9172	·792 3784	·613 4815	·776 8449	·287 2582	·789 7091	38
23	·610 0875	·769 9878	·298 7218	·792 3340	·613 5389	·776 9616	·287 0650	·789 6645	37
24	·610 1452	·770 1037	·298 5265	·792 2896	·613 5964	·777 0782	·286 8718	·789 6198	36
25	0·610 2028	0·770 2195	1·298 3311	0·792 2453	0·613 6538	0·777 1948	1·286 6787	0·789 5752	35
26	·610 2604	·770 3354	·298 1359	·792 2009	·613 7112	·777 3115	·286 4856	·789 5306	34
27	·610 3180	·770 4513	·297 9406	·792 1565	·613 7686	·777 4282	·286 2925	·789 4860	33
28	·610 3756	·770 5672	·297 7454	·792 1121	·613 8260	·777 5448	·286 0995	·789 4413	32
29	·610 4332	·770 6831	·297 5502	·792 0677	·613 8834	·777 6615	·285 9065	·789 3967	31
30	0·610 4908	0·770 7990	1·297 3551	0·792 0233	0·613 9408	0·777 7782	1·285 7135	0·789 3520	30
31	·610 5484	·770 9149	·297 1600	·791 9789	·613 9982	·777 8950	·285 5206	·789 3074	29
32	·610 6060	·771 0309	·296 9649	·791 9345	·614 0556	·778 0117	·285 3277	·789 2627	28
33	·610 6636	·771 1469	·296 7699	·791 8901	·614 1130	·778 1284	·285 1349	·789 2181	27
34	·610 7212	·771 2628	·296 5749	·791 8457	·614 1704	·778 2452	·284 9421	·789 1734	26
35	0·610 7788	0·771 3788	1·296 3799	0·791 8013	0·614 2278	0·778 3620	1·284 7493	0·789 1288	25
36	·610 8363	·771 4948	·296 1850	·791 7569	·614 2852	·778 4788	·284 5566	·789 0841	24
37	·610 8939	·771 6108	·295 9901	·791 7125	·614 3426	·778 5956	·284 3639	·789 0394	23
38	·610 9515	·771 7269	·295 7953	·791 6680	·614 4000	·778 7124	·284 1712	·788 9947	22
39	·611 0091	·771 8429	·295 6005	·791 6236	·614 4573	·778 8292	·283 9786	·788 9500	21
40	0·611 0666	0·771 9589	1·295 4057	0·791 5792	0·614 5147	0·778 9460	1·283 7860	0·788 9054	20
41	·611 1242	·772 0750	·295 2109	·791 5347	·614 5721	·779 0629	·283 5934	·788 8607	19
42	·611 1817	·772 1911	·295 0162	·791 4903	·614 6294	·779 1798	·283 4009	·788 8160	18
43	·611 2393	·772 3072	·294 8216	·791 4458	·614 6868	·779 2966	·283 2084	·788 7713	17
44	·611 2969	·772 4233	·294 6270	·791 4014	·614 7442	·779 4135	·283 0160	·788 7266	16
45	0·611 3544	0·772 5394	1·294 4324	0·791 3569	0·614 8015	0·779 5304	1·282 8235	0·788 6819	15
46	·611 4120	·772 6555	·294 2378	·791 3125	·614 8589	·779 6474	·282 6312	·788 6372	14
47	·611 4695	·772 7717	·294 0433	·791 2680	·614 9162	·779 7643	·282 4388	·788 5924	13
48	·611 5270	·772 8878	·293 8488	·791 2235	·614 9736	·779 8812	·282 2465	·788 5477	12
49	·611 5846	·773 0040	·293 6544	·791 1791	·615 0309	·779 9982	·282 0542	·788 5030	11
50	0·611 6421	0·773 1202	1·293 4600	0·791 1346	0·615 0883	0·780 1152	1·281 8620	0·788 4583	10
51	·611 6996	·773 2364	·293 2656	·791 0901	·615 1456	·780 2322	·281 6698	·788 4135	09
52	·611 7572	·773 3526	·293 0713	·791 0456	·615 2029	·780 3492	·281 4776	·788 3688	08
53	·611 8147	·773 4688	·292 8770	·791 0011	·615 2603	·780 4662	·281 2855	·788 3241	07
54	·611 8722	·773 5850	·292 6827	·790 9566	·615 3176	·780 5832	·281 0934	·788 2793	06
55	0·611 9297	0·773 7013	1·292 4885	0·790 9121	0·615 3749	0·780 7002	1·280 9014	0·788 2346	05
56	·611 9873	·773 8176	·292 2943	·790 8676	·615 4322	·780 8173	·280 7094	·788 1898	04
57	·612 0448	·773 9338	·292 1001	·790 8231	·615 4895	·780 9344	·280 5174	·788 1451	03
58	·612 1023	·774 0501	·291 9060	·790 7786	·615 5469	·781 0514	·280 3254	·788 1003	02
59	·612 1598	·774 1664	·291 7119	·790 7341	·615 6042	·781 1685	·280 1335	·788 0555	01
60	0·612 2173	0·774 2827	1·291 5179	0·790 6896	0·615 6615	0·781 2856	1·279 9416	0·788 0108	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	575–577	1163–1155	1940–1962	445–442	573–575	1171–1163	1919–1940	448–445	d

$3^{h}\ 29^{m}$ | $3^{h}\ 28^{m}$

$2^h\ 32^m$ $2^h\ 33^m$

d	573–571	1171–1179	1918–1897	448–451	572–569	1179–1187	1898–1877	450–453	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·615 6615	0·781 2856	1·279 9416	0·788 0108	0·619 0939	0·788 3364	1·268 4940	0·785 3169	60
01	·615 7188	·781 4027	·279 7498	·787 9660	·619 1511	·788 4544	·268 3042	·785 2719	59
02	·615 7761	·781 5199	·279 5580	·787 9212	·619 2082	·788 5723	·268 1145	·785 2269	58
03	·615 8334	·781 6370	·279 3662	·787 8764	·619 2653	·788 6902	·267 9249	·785 1818	57
04	·615 8907	·781 7542	·279 1745	·787 8316	·619 3224	·788 8082	·267 7353	·785 1368	56
05	0·615 9480	0·781 8714	1·278 9828	0·787 7868	0·619 3795	0·788 9262	1·267 5457	0·785 0918	55
06	·616 0053	·781 9885	·278 7911	·787 7420	·619 4365	·789 0442	·267 3562	·785 0467	54
07	·616 0625	·782 1057	·278 5995	·787 6972	·619 4936	·789 1622	·267 1666	·785 0017	53
08	·616 1198	·782 2229	·278 4079	·787 6524	·619 5507	·789 2802	·266 9772	·784 9566	52
09	·616 1771	·782 3402	·278 2163	·787 6076	·619 6078	·789 3982	·266 7877	·784 9116	51
10	0·616 2344	0·782 4574	1·278 0248	0·787 5628	0·619 6649	0·789 5163	1·266 5983	0·784 8665	50
11	·616 2916	·782 5747	·277 8333	·787 5180	·619 7220	·789 6343	·266 4090	·784 8214	49
12	·616 3489	·782 6919	·277 6419	·787 4732	·619 7790	·789 7524	·266 2196	·784 7764	48
13	·616 4062	·782 8092	·277 4505	·787 4284	·619 8361	·789 8705	·266 0303	·784 7313	47
14	·616 4634	·782 9265	·277 2591	·787 3835	·619 8932	·789 9886	·265 8411	·784 6862	46
15	0·616 5207	0·783 0438	1·277 0678	0·787 3387	0·619 9502	0·790 1067	1·265 6518	0·784 6411	45
16	·616 5780	·783 1611	·276 8765	·787 2939	·620 0073	·790 2248	·265 4626	·784 5961	44
17	·616 6352	·783 2785	·276 6852	·787 2490	·620 0643	·790 3430	·265 2735	·784 5510	43
18	·616 6925	·783 3958	·276 4939	·787 2042	·620 1214	·790 4611	·265 0843	·784 5059	42
19	·616 7497	·783 5132	·276 3027	·787 1593	·620 1784	·790 5793	·264 8952	·784 4608	41
20	0·616 8069	0·783 6305	1·276 1116	0·787 1145	0·620 2355	0·790 6975	1·264 7062	0·784 4157	40
21	·616 8642	·783 7479	·275 9205	·787 0696	·620 2925	·790 8157	·264 5172	·784 3706	39
22	·616 9214	·783 8653	·275 7294	·787 0248	·620 3496	·790 9339	·264 3282	·784 3254	38
23	·616 9786	·783 9827	·275 5383	·786 9799	·620 4066	·791 0521	·264 1392	·784 2803	37
24	·617 0359	·784 1002	·275 3473	·786 9350	·620 4636	·791 1703	·263 9503	·784 2352	36
25	0·617 0931	0·784 2176	1·275 1563	0·786 8901	0·620 5207	0·791 2886	1·263 7614	0·784 1901	35
26	·617 1503	·784 3350	·274 9653	·786 8453	·620 5777	·791 4069	·263 5726	·784 1450	34
27	·617 2075	·784 4525	·274 7744	·786 8004	·620 6347	·791 5251	·263 3838	·784 0998	33
28	·617 2648	·784 5700	·274 5835	·786 7555	·620 6917	·791 6434	·263 1950	·784 0547	32
29	·617 3220	·784 6875	·274 3927	·786 7106	·620 7488	·791 7617	·263 0062	·784 0096	31
30	0·617 3792	0·784 8050	1·274 2019	0·786 6657	0·620 8058	0·791 8800	1·262 8175	0·783 9644	30
31	·617 4364	·784 9225	·274 0111	·786 6208	·620 8628	·791 9984	·262 6289	·783 9193	29
32	·617 4936	·785 0400	·273 8204	·786 5759	·620 9198	·792 1167	·262 4402	·783 8741	28
33	·617 5508	·785 1576	·273 6297	·786 5310	·620 9768	·792 2351	·262 2516	·783 8290	27
34	·617 6080	·785 2752	·273 4390	·786 4861	·621 0338	·792 3534	·262 0630	·783 7838	26
35	0·617 6652	0·785 3927	1·273 2484	0·786 4412	0·621 0908	0·792 4718	1·261 8745	0·783 7386	25
36	·617 7224	·785 5103	·273 0578	·786 3963	·621 1478	·792 5902	·261 6860	·783 6935	24
37	·617 7796	·785 6279	·272 8672	·786 3513	·621 2048	·792 7086	·261 4975	·783 6483	23
38	·617 8367	·785 7455	·272 6767	·786 3064	·621 2618	·792 8271	·261 3091	·783 6031	22
39	·617 8939	·785 8632	·272 4862	·786 2615	·621 3187	·792 9455	·261 1207	·783 5579	21
40	0·617 9511	0·785 9808	1·272 2957	0·786 2165	0·621 3757	0·793 0640	1·260 9323	0·783 5127	20
41	·618 0083	·786 0984	·272 1053	·786 1716	·621 4327	·793 1824	·260 7440	·783 4675	19
42	·618 0654	·786 2161	·271 9149	·786 1266	·621 4897	·793 3009	·260 5557	·783 4224	18
43	·618 1226	·786 3338	·271 7246	·786 0817	·621 5466	·793 4194	·260 3675	·783 3772	17
44	·618 1798	·786 4515	·271 5342	·786 0367	·621 6036	·793 5379	·260 1792	·783 3320	16
45	0·618 2369	0·786 5692	1·271 3440	0·785 9918	0·621 6606	0·793 6564	1·259 9910	0·783 2867	15
46	·618 2941	·786 6869	·271 1537	·785 9468	·621 7175	·793 7750	·259 8029	·783 2415	14
47	·618 3512	·786 8047	·270 9635	·785 9019	·621 7745	·793 8935	·259 6148	·783 1963	13
48	·618 4084	·786 9224	·270 7733	·785 8569	·621 8314	·794 0121	·259 4267	·783 1511	12
49	·618 4655	·787 0402	·270 5832	·785 8119	·621 8884	·794 1307	·259 2386	·783 1059	11
50	0·618 5227	0·787 1579	1·270 3931	0·785 7669	0·621 9453	0·794 2493	1·259 0506	0·783 0607	10
51	·618 5798	·787 2757	·270 2030	·785 7220	·622 0023	·794 3679	·258 8626	·783 0154	09
52	·618 6370	·787 3935	·270 0130	·785 6770	·622 0592	·794 4865	·258 6747	·782 9702	08
53	·618 6941	·787 5113	·269 8230	·785 6320	·622 1162	·794 6051	·258 4867	·782 9249	07
54	·618 7512	·787 6292	·269 6330	·785 5870	·622 1731	·794 7238	·258 2989	·782 8797	06
55	0·618 8084	0·787 7470	1·269 4431	0·785 5420	0·622 2300	0·794 8424	1·258 1110	0·782 8345	05
56	·618 8655	·787 8649	·269 2532	·785 4970	·622 2870	·794 9611	·257 9232	·782 7892	04
57	·618 9226	·787 9827	·269 0633	·785 4520	·622 3439	·795 0798	·257 7354	·782 7439	03
58	·618 9797	·788 1006	·268 8735	·785 4070	·622 4008	·795 1985	·257 5477	·782 6987	02
59	·619 0368	·788 2185	·268 6837	·785 3620	·622 4577	·795 3172	·257 3600	·782 6534	01
60	0·619 0939	0·788 3364	1·268 4940	0·785 3169	0·622 5146	0·795 4359	1·257 1723	0·782 6082	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	571–573	1179–1171	1897–1918	451–448	569–572	1187–1179	1877–1898	453–450	d

$3^h\ 27^m$ $3^h\ 26^m$

$2^h\ 34^m$ $2^h\ 35^m$

d	570–567	1187–1196	1876–1856	452–455	567–565	1195–1204	1856–1836	455–458	d
	sin	tan	cot	cos	sin	tan	cot	cos	
s									
00	0·622 5146	0·795 4359	1·257 1723	0·782 6082	0·625 9235	0·802 5849	1·245 9742	0·779 8845	60
01	·622 5715	·795 5547	·256 9847	·782 5629	·625 9802	·802 7044	·245 7886	·779 8390	59
02	·622 6285	·795 6734	·256 7971	·782 5176	·626 0369	·802 8240	·245 6030	·779 7934	58
03	·622 6854	·795 7922	·256 6095	·782 4723	·626 0936	·802 9436	·245 4175	·779 7479	57
04	·622 7423	·795 9110	·256 4219	·782 4270	·626 1503	·803 0632	·245 2320	·779 7024	56
05	0·622 7992	0·796 0298	1·256 2344	0·782 3818	0·626 2070	0·803 1829	1·245 0465	0·779 6568	55
06	·622 8561	·796 1486	·256 0470	·782 3365	·626 2637	·803 3025	·244 8611	·779 6113	54
07	·622 9129	·796 2674	·255 8595	·782 2912	·626 3204	·803 4222	·244 6757	·779 5658	53
08	·622 9698	·796 3862	·255 6721	·782 2459	·626 3771	·803 5418	·244 4993	·779 5202	52
09	·623 0267	·796 5051	·255 4848	·782 2006	·626 4338	·803 6615	·244 3050	·779 4747	51
10	0·623 0836	0·796 6240	1·255 2974	0·782 1552	0·626 4905	0·803 7812	1·244 1197	0·779 4291	50
11	·623 1405	·796 7428	·255 1101	·782 1099	·626 5471	·803 9009	·243 9344	·779 3835	49
12	·623 1974	·796 8617	·254 9229	·782 0646	·626 6038	·804 0206	·243 7492	·779 3380	48
13	·623 2542	·796 9806	·254 7356	·782 0193	·626 6605	·804 1404	·243 5640	·779 2924	47
14	·623 3111	·797 0995	·254 5484	·781 9740	·626 7172	·804 2601	·243 3788	·779 2468	46
15	0·623 3680	0·797 2185	1·254 3613	0·781 9286	0·626 7738	0·804 3799	1·243 1937	0·779 2012	45
16	·623 4248	·797 3374	·254 1742	·781 8833	·626 8305	·804 4997	·243 0086	·779 1557	44
17	·623 4817	·797 4564	·253 9871	·781 8380	·626 8871	·804 6195	·242 8235	·779 1101	43
18	·623 5385	·797 5754	·253 8000	·781 7926	·626 9438	·804 7393	·242 6385	·779 0645	42
19	·623 5954	·797 6944	·253 6130	·781 7473	·627 0005	·804 8591	·242 4535	·779 0189	41
20	0·623 6522	0·797 8134	1·253 4260	0·781 7019	0·627 0571	0·804 9790	1·242 2685	0·778 9733	40
21	·623 7091	·797 9324	·253 2390	·781 6566	·627 1138	·805 0988	·242 0836	·778 9277	39
22	·623 7659	·798 0514	·253 0521	·781 6112	·627 1704	·805 2187	·241 8987	·778 8821	38
23	·623 8228	·798 1705	·252 8652	·781 5658	·627 2270	·805 3386	·241 7138	·778 8365	37
24	·623 8796	·798 2895	·252 6784	·781 5205	·627 2837	·805 4584	·241 5290	·778 7909	36
25	0·623 9364	0·798 4086	1·252 4915	0·781 4751	0·627 3403	0·805 5784	1·241 3442	0·778 7452	35
26	·623 9933	·798 5277	·252 3048	·781 4297	·627 3969	·805 6983	·241 1594	·778 6996	34
27	·624 0501	·798 6468	·252 1180	·781 3843	·627 4536	·805 8182	·240 9747	·778 6540	33
28	·624 1069	·798 7659	·251 9313	·781 3390	·627 5102	·805 9382	·240 7900	·778 6084	32
29	·624 1637	·798 8850	·251 7446	·781 2936	·627 5668	·806 0581	·240 6053	·778 5627	31
30	0·624 2205	0·799 0042	1·251 5579	0·781 2482	0·627 6234	0·806 1781	1·240 4207	0·778 5171	30
31	·624 2774	·799 1233	·251 3713	·781 2028	·627 6800	·806 2981	·240 2361	·778 4714	29
32	·624 3342	·799 2425	·251 1848	·781 1574	·627 7366	·806 4181	·240 0515	·778 4258	28
33	·624 3910	·799 3617	·250 9982	·781 1120	·627 7933	·806 5381	·239 8670	·778 3801	27
34	·624 4478	·799 4809	·250 8117	·781 0666	·627 8499	·806 6582	·239 6825	·778 3345	26
35	0·624 5046	0·799 6001	1·250 6252	0·781 0212	0·627 9065	0·806 7782	1·239 4980	0·778 2888	25
36	·624 5614	·799 7193	·250 4388	·780 9757	·627 9631	·806 8983	·239 3136	·778 2431	24
37	·624 6182	·799 8385	·250 2523	·780 9303	·628 0197	·807 0184	·239 1292	·778 1975	23
38	·624 6749	·799 9578	·250 0660	·780 8849	·628 0762	·807 1384	·238 9448	·778 1518	22
39	·624 7317	·800 0770	·249 8796	·780 8395	·628 1328	·807 2586	·238 7605	·778 1061	21
40	0·624 7885	0·800 1963	1·249 6933	0·780 7940	0·628 1894	0·807 3787	1·238 5762	0·778 0604	20
41	·624 8453	·800 3156	·249 5070	·780 7486	·628 2460	·807 4988	·238 3919	·778 0148	19
42	·624 9021	·800 4349	·249 3208	·780 7031	·628 3026	·807 6190	·238 2077	·777 9691	18
43	·624 9588	·800 5543	·249 1346	·780 6577	·628 3591	·807 7391	·238 0235	·777 9234	17
44	·625 0156	·800 6736	·248 9484	·780 6123	·628 4157	·807 8593	·237 8393	·777 8777	16
45	0·625 0724	0·800 7929	1·248 7623	0·780 5668	0·628 4723	0·807 9795	1·237 6552	0·777 8320	15
46	·625 1291	·800 9123	·248 5762	·780 5213	·628 5288	·808 0997	·237 4711	·777 7863	14
47	·625 1859	·801 0317	·248 3901	·780 4759	·628 5854	·808 2199	·237 2870	·777 7406	13
48	·625 2427	·801 1511	·248 2040	·780 4304	·628 6420	·808 3401	·237 1030	·777 6949	12
49	·625 2994	·801 2705	·248 0180	·780 3849	·628 6985	·808 4604	·236 9190	·777 6491	11
50	0·625 3562	0·801 3899	1·247 8321	0·780 3395	0·628 7551	0·808 5806	1·236 7350	0·777 6034	10
51	·625 4129	·801 5093	·247 6461	·780 2940	·628 8116	·808 7009	·236 5511	·777 5577	09
52	·625 4696	·801 6288	·247 4602	·780 2485	·628 8682	·808 8212	·236 3672	·777 5120	08
53	·625 5264	·801 7482	·247 2743	·780 2030	·628 9247	·808 9415	·236 1833	·777 4662	07
54	·625 5831	·801 8677	·247 0885	·780 1575	·628 9812	·809 0618	·235 9995	·777 4205	06
55	0·625 6399	0·801 9872	1·246 9027	0·780 1120	0·629 0378	0·809 1822	1·235 8157	0·777 3747	05
56	·625 6966	·802 1067	·246 7169	·780 0665	·629 0943	·809 3025	·235 6319	·777 3290	04
57	·625 7533	·802 2262	·246 5312	·780 0210	·629 1508	·809 4229	·235 4482	·777 2832	03
58	·625 8100	·802 3457	·246 3455	·779 9755	·629 2074	·809 5432	·235 2645	·777 2375	02
59	·625 8668	·802 4653	·246 1598	·779 9300	·629 2639	·809 6636	·235 0808	·777 1917	01
60	0·625 9235	0·802 5849	1·245 9742	0·779 8845	0·629 3204	0·809 7840	1·234 8972	0·777 1460	00
									s
	cos	cot	tan	sin	cos	cot	tan	sin	
d	567–570	1196–1187	1856–1876	455–452	565–567	1204–1195	1836–1856	458–455	d

$3^h\ 25^m$ $3^h\ 24^m$

2ʰ 36ᵐ **2ʰ 37ᵐ**

d	565–563	1204–1213	1836–1816	457–461	564–561	1212–1222	1817–1797	460–463	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·629 3204	0·809 7840	1·234 8972	0·777 1460	0·632 7053	0·817 0343	1·223 9389	0·774 3926	60
01	·629 3769	·809 9044	·234 7136	·777 1002	·632 7616	·817 1555	·223 7572	·774 3466	59
02	·629 4334	·810 0249	·234 5300	·777 0544	·632 8180	·817 2768	·223 5756	·774 3006	58
03	·629 4899	·810 1453	·234 3464	·777 0086	·632 8743	·817 3981	·223 3940	·774 2546	57
04	·629 5464	·810 2658	·234 1629	·776 9629	·632 9306	·817 5195	·223 2125	·774 2086	56
05	0·629 6029	0·810 3863	1·233 9795	0·776 9171	0·632 9869	0·817 6408	1·223 0310	0·774 1625	55
06	·629 6594	·810 5067	·233 7960	·776 8713	·633 0432	·817 7621	·222 8495	·774 1165	54
07	·629 7159	·810 6272	·233 6126	·776 8255	·633 0995	·817 8835	·222 6680	·774 0705	53
08	·629 7724	·810 7478	·233 4292	·776 7797	·633 1557	·818 0049	·222 4866	·774 0244	52
09	·629 8289	·810 8683	·233 2459	·776 7339	·633 2120	·818 1263	·222 3052	·773 9784	51
10	0·629 8854	0·810 9888	1·233 0626	0·776 6881	0·633 2683	0·818 2477	1·222 1239	0·773 9323	50
11	·629 9419	·811 1094	·232 8793	·776 6423	·633 3246	·818 3691	·221 9425	·773 8863	49
12	·629 9983	·811 2300	·232 6961	·776 5965	·633 3809	·818 4905	·221 7613	·773 8402	48
13	·630 0548	·811 3506	·232 5129	·776 5507	·633 4371	·818 6120	·221 5800	·773 7941	47
14	·630 1113	·811 4712	·232 3297	·776 5048	·633 4934	·818 7334	·221 3988	·773 7481	46
15	0·630 1678	0·811 5918	1·232 1465	0·776 4590	0·633 5497	0·818 8549	1·221 2176	0·773 7020	45
16	·630 2242	·811 7124	·231 9634	·776 4132	·633 6059	·818 9764	·221 0364	·773 6559	44
17	·630 2807	·811 8330	·231 7804	·776 3674	·633 6622	·819 0979	·220 8553	·773 6099	43
18	·630 3371	·811 9537	·231 5973	·776 3215	·633 7185	·819 2194	·220 6742	·773 5638	42
19	·630 3936	·812 0744	·231 4143	·776 2757	·633 7747	·819 3410	·220 4931	·773 5177	41
20	0·630 4500	0·812 1951	1·231 2313	0·776 2298	0·633 8310	0·819 4625	1·220 3121	0·773 4716	40
21	·630 5065	·812 3158	·231 0484	·776 1840	·633 8872	·819 5841	·220 1311	·773 4255	39
22	·630 5629	·812 4365	·230 8655	·776 1381	·633 9435	·819 7056	·219 9501	·773 3794	38
23	·630 6194	·812 5572	·230 6826	·776 0923	·633 9997	·819 8272	·219 7692	·773 3333	37
24	·630 6758	·812 6780	·230 4997	·776 0464	·634 0559	·819 9488	·219 5883	·773 2872	36
25	0·630 7322	0·812 7987	1·230 3169	0·776 0005	0·634 1122	0·820 0705	1·219 4074	0·773 2411	35
26	·630 7887	·812 9195	·230 1341	·775 9547	·634 1684	·820 1921	·219 2266	·773 1950	34
27	·630 8451	·813 0403	·229 9514	·775 9088	·634 2246	·820 3138	·219 0458	·773 1488	33
28	·630 9015	·813 1611	·229 7687	·775 8629	·634 2808	·820 4354	·218 8650	·773 1027	32
29	·630 9579	·813 2819	·229 5860	·775 8170	·634 3371	·820 5571	·218 6842	·773 0566	31
30	0·631 0144	0·813 4027	1·229 4033	0·775 7711	0·634 3933	0·820 6788	1·218 5035	0·773 0105	30
31	·631 0708	·813 5236	·229 2207	·775 7253	·634 4495	·820 8005	·218 3228	·772 9643	29
32	·631 1272	·813 6444	·229 0381	·775 6794	·634 5057	·820 9222	·218 1422	·772 9182	28
33	·631 1836	·813 7653	·228 8556	·775 6335	·634 5619	·821 0440	·217 9616	·772 8720	27
34	·631 2400	·813 8862	·228 6730	·775 5876	·634 6181	·821 1657	·217 7810	·772 8259	26
35	0·631 2964	0·814 0071	1·228 4905	0·775 5417	0·634 6743	0·821 2875	1·217 6004	0·772 7797	25
36	·631 3528	·814 1280	·228 3081	·775 4957	·634 7305	·821 4093	·217 4199	·772 7336	24
37	·631 4092	·814 2489	·228 1257	·775 4498	·634 7867	·821 5311	·217 2394	·772 6874	23
38	·631 4656	·814 3699	·227 9433	·775 4039	·634 8429	·821 6529	·217 0590	·772 6412	22
39	·631 5220	·814 4908	·227 7609	·775 3580	·634 8991	·821 7747	·216 8786	·772 5951	21
40	0·631 5784	0·814 6118	1·227 5786	0·775 3121	0·634 9553	0·821 8965	1·216 6982	0·772 5489	20
41	·631 6347	·814 7328	·227 3963	·775 2661	·635 0114	·822 0184	·216 5178	·772 5027	19
42	·631 6911	·814 8538	·227 2140	·775 2202	·635 0676	·822 1403	·216 3375	·772 4565	18
43	·631 7475	·814 9748	·227 0318	·775 1742	·635 1238	·822 2621	·216 1572	·772 4104	17
44	·631 8039	·815 0958	·226 8496	·775 1283	·635 1800	·822 3840	·215 9769	·772 3642	16
45	0·631 8602	0·815 2169	1·226 6674	0·775 0824	0·635 2361	0·822 5059	1·215 7967	0·772 3180	15
46	·631 9166	·815 3379	·226 4853	·775 0364	·635 2923	·822 6279	·215 6165	·772 2718	14
47	·631 9729	·815 4590	·226 3032	·774 9904	·635 3485	·822 7498	·215 4363	·772 2256	13
48	·632 0293	·815 5801	·226 1211	·774 9445	·635 4046	·822 8718	·215 2562	·772 1794	12
49	·632 0857	·815 7012	·225 9391	·774 8985	·635 4608	·822 9937	·215 0761	·772 1332	11
50	0·632 1420	0·815 8223	1·225 7571	0·774 8526	0·635 5169	0·823 1157	1·214 8960	0·772 0869	10
51	·632 1984	·815 9434	·225 5751	·774 8066	·635 5731	·823 2377	·214 7160	·772 0407	09
52	·632 2547	·816 0646	·225 3932	·774 7606	·635 6292	·823 3597	·214 5359	·771 9945	08
53	·632 3110	·816 1858	·225 2113	·774 7146	·635 6853	·823 4818	·214 3560	·771 9483	07
54	·632 3674	·816 3069	·225 0294	·774 6686	·635 7415	·823 6038	·214 1760	·771 9021	06
55	0·632 4237	0·816 4281	1·224 8476	0·774 6227	0·635 7976	0·823 7259	1·213 9961	0·771 8558	05
56	·632 4800	·816 5493	·224 6658	·774 5767	·635 8537	·823 8479	·213 8162	·771 8096	04
57	·632 5364	·816 6705	·224 4840	·774 5307	·635 9099	·823 9700	·213 6364	·771 7633	03
58	·632 5927	·816 7918	·224 3023	·774 4847	·635 9660	·824 0921	·213 4565	·771 7171	02
59	·632 6490	·816 9130	·224 1205	·774 4387	·636 0221	·824 2143	·213 2768	·771 6708	01
60	0·632 7053	0·817 0343	1·223 9389	0·774 3926	0·636 0782	0·824 3364	1·213 0970	0·771 6246	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	563–565	1213–1204	1816–1836	461–457	561–564	1222–1212	1797–1817	463–460	d

3ʰ 23ᵐ **3ʰ 22ᵐ**

2^h 38^m 2^h 39^m

d	561–559	1221–1230	1797–1779	462–465	559–557	1230–1239	1778–1760	465–468	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·636 0782	0·824 3364	1·213 0970	0·771 6246	0·639 4390	0·831 6912	1·202 3693	0·768 8418	60
01	·636 1343	·824 4585	·212 9173	·771 5783	·639 4949	·831 8143	·202 1915	·768 7953	59
02	·636 1904	·824 5807	·212 7376	·771 5321	·639 5508	·831 9373	·202 0137	·768 7488	58
03	·636 2465	·824 7029	·212 5579	·771 4858	·639 6067	·832 0604	·201 8359	·768 7023	57
04	·636 3026	·824 8251	·212 3783	·771 4395	·639 6626	·832 1834	·201 6581	·768 6558	56
05	0·636 3587	0·824 9473	1·212 1987	0·771 3932	0·639 7185	0·832 3065	1·201 4804	0·768 6093	55
06	·636 4148	·825 0695	·212 0191	·771 3470	·639 7744	·832 4296	·201 3027	·768 5628	54
07	·636 4709	·825 1917	·211 8396	·771 3007	·639 8303	·832 5528	·201 1251	·768 5162	53
08	·636 5270	·825 3140	·211 6601	·771 2544	·639 8862	·832 6759	·200 9475	·768 4697	52
09	·636 5831	·825 4362	·211 4806	·771 2081	·639 9421	·832 7990	·200 7699	·768 4232	51
10	0·636 6392	0·825 5585	1·211 3012	0·771 1618	0·639 9980	0·832 9222	1·200 5923	0·768 3766	50
11	·636 6953	·825 6808	·211 1218	·771 1155	·640 0538	·833 0454	·200 4148	·768 3301	49
12	·636 7513	·825 8031	·210 9424	·771 0692	·640 1097	·833 1686	·200 2373	·768 2835	48
13	·636 8074	·825 9254	·210 7631	·771 0229	·640 1656	·833 2918	·200 0598	·768 2370	47
14	·636 8635	·826 0478	·210 5837	·770 9766	·640 2214	·833 4150	·199 8824	·768 1904	46
15	0·636 9196	0·826 1701	1·210 4045	0·770 9303	0·640 2773	0·833 5383	1·199 7050	0·768 1439	45
16	·636 9756	·826 2925	·210 2252	·770 8840	·640 3332	·833 6615	·199 5276	·768 0973	44
17	·637 0317	·826 4149	·210 0460	·770 8376	·640 3890	·833 7848	·199 3502	·768 0507	43
18	·637 0877	·826 5373	·209 8668	·770 7913	·640 4449	·833 9081	·199 1729	·768 0041	42
19	·637 1438	·826 6597	·209 6877	·770 7450	·640 5007	·834 0314	·198 9957	·767 9576	41
20	0·637 1998	0·826 7821	1·209 5085	0·770 6986	0·640 5566	0·834 1547	1·198 8184	0·767 9110	40
21	·637 2559	·826 9045	·209 3294	·770 6523	·640 6124	·834 2780	·198 6412	·767 8644	39
22	·637 3119	·827 0270	·209 1504	·770 6059	·640 6682	·834 4014	·198 4640	·767 8178	38
23	·637 3680	·827 1495	·208 9713	·770 5596	·640 7241	·834 5247	·198 2868	·767 7712	37
24	·637 4240	·827 2719	·208 7924	·770 5132	·640 7799	·834 6481	·198 1097	·767 7246	36
25	0·637 4800	0·827 3944	1·208 6134	0·770 4669	0·640 8357	0·834 7715	1·197 9326	0·767 6780	35
26	·637 5360	·827 5170	·208 4344	·770 4205	·640 8916	·834 8949	·197 7555	·767 6314	34
27	·637 5921	·827 6395	·208 2555	·770 3742	·640 9474	·835 0183	·197 5785	·767 5848	33
28	·637 6481	·827 7620	·208 0767	·770 3278	·641 0032	·835 1418	·197 4015	·767 5382	32
29	·637 7041	·827 8846	·207 8978	·770 2814	·641 0590	·835 2652	·197 2245	·767 4916	31
30	0·637 7601	0·828 0072	1·207 7190	0·770 2350	0·641 1148	0·835 3887	1·197 0476	0·767 4450	30
31	·637 8161	·828 1297	·207 5402	·770 1887	·641 1706	·835 5122	·196 8707	·767 3983	29
32	·637 8721	·828 2523	·207 3615	·770 1423	·641 2264	·835 6357	·196 6938	·767 3517	28
33	·637 9282	·828 3750	·207 1828	·770 0959	·641 2822	·835 7592	·196 5169	·767 3051	27
34	·637 9842	·828 4976	·207 0041	·770 0495	·641 3380	·835 8827	·196 3401	·767 2584	26
35	0·638 0402	0·828 6202	1·206 8255	0·770 0031	0·641 3938	0·836 0062	1·196 1633	0·767 2118	25
36	·638 0961	·828 7429	·206 6468	·769 9567	·641 4496	·836 1298	·195 9866	·767 1652	24
37	·638 1521	·828 8656	·206 4682	·769 9103	·641 5054	·836 2534	·195 8099	·767 1185	23
38	·638 2081	·828 9883	·206 2897	·769 8639	·641 5612	·836 3769	·195 6332	·767 0718	22
39	·638 2641	·829 1110	·206 1112	·769 8175	·641 6170	·836 5005	·195 4565	·767 0252	21
40	0·638 3201	0·829 2337	1·205 9327	0·769 7710	0·641 6728	0·836 6242	1·195 2799	0·766 9785	20
41	·638 3761	·829 3564	·205 7542	·769 7246	·641 7285	·836 7478	·195 1033	·766 9319	19
42	·638 4320	·829 4792	·205 5758	·769 6782	·641 7843	·836 8714	·194 9267	·766 8852	18
43	·638 4880	·829 6019	·205 3974	·769 6318	·641 8401	·836 9951	·194 7501	·766 8385	17
44	·638 5440	·829 7247	·205 2190	·769 5853	·641 8958	·837 1188	·194 5736	·766 7918	16
45	0·638 5999	0·829 8475	1·205 0407	0·769 5389	0·641 9516	0·837 2425	1·194 3971	0·766 7452	15
46	·638 6559	·829 9703	·204 8623	·769 4925	·642 0074	·837 3662	·194 2207	·766 6985	14
47	·638 7119	·830 0932	·204 6841	·769 4460	·642 0631	·837 4899	·194 0443	·766 6518	13
48	·638 7678	·830 2160	·204 5058	·769 3996	·642 1189	·837 6136	·193 8679	·766 6051	12
49	·638 8238	·830 3388	·204 3276	·769 3531	·642 1746	·837 7374	·193 6915	·766 5584	11
50	0·638 8797	0·830 4617	1·204 1494	0·769 3066	0·642 2304	0·837 8611	1·193 5152	0·766 5117	10
51	·638 9357	·830 5846	·203 9713	·769 2602	·642 2861	·837 9849	·193 3389	·766 4650	09
52	·638 9916	·830 7075	·203 7932	·769 2137	·642 3418	·838 1087	·193 1626	·766 4183	08
53	·639 0475	·830 8304	·203 6151	·769 1672	·642 3976	·838 2325	·192 9864	·766 3716	07
54	·639 1035	·830 9533	·203 4370	·769 1208	·642 4533	·838 3564	·192 8102	·766 3248	06
55	0·639 1594	0·831 0763	1·203 2590	0·769 0743	0·642 5090	0·838 4802	1·192 6340	0·766 2781	05
56	·639 2153	·831 1992	·203 0810	·769 0278	·642 5647	·838 6041	·192 4579	·766 2314	04
57	·639 2713	·831 3222	·202 9030	·768 9813	·642 6205	·838 7279	·192 2818	·766 1847	03
58	·639 3272	·831 4452	·202 7251	·768 9348	·642 6762	·838 8518	·192 1057	·766 1379	02
59	·639 3831	·831 5682	·202 5472	·768 8883	·642 7319	·838 9757	·191 9296	·766 0912	01
60	0·639 4390	0·831 6912	1·202 3693	0·768 8418	0·642 7876	0·839 0996	1·191 7536	0·766 0444	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	559–561	1230–1221	1779–1797	465–462	557–559	1239–1230	1760–1778	468–465	d

3^h 21^m 3^h 20^m

$2^{h}\ 40^{m}$ $2^{h}\ 41^{m}$

d	557–555	1239–1249	1760–1742	467–470	555–553	1248–1258	1742–1724	470–473	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·642 7876	0·839 0996	1·191 7536	0·766 0444	0·646 1240	0·846 5625	1·181 2477	0·763 2325	60
01	·642 8433	·839 2236	·191 5776	·765 9977	·646 1795	·846 6873	·181 0735	·763 1855	59
02	·642 8990	·839 3475	·191 4016	·765 9509	·646 2350	·846 8122	·180 8994	·763 1385	58
03	·642 9547	·839 4715	·191 2257	·765 9042	·646 2905	·846 9371	·180 7253	·763 0915	57
04	·643 0104	·839 5955	·191 0498	·765 8574	·646 3460	·847 0620	·180 5512	·763 0445	56
05	0·643 0661	0·839 7194	1·190 8739	0·765 8107	0·646 4015	0·847 1869	1·180 3771	0·762 9975	55
06	·643 1218	·839 8435	·190 6981	·765 7639	·646 4569	·847 3118	·180 2031	·762 9505	54
07	·643 1775	·839 9675	·190 5223	·765 7171	·646 5124	·847 4367	·180 0291	·762 9035	53
08	·643 2332	·840 0915	·190 3465	·765 6704	·646 5679	·847 5617	·179 8551	·762 8564	52
09	·643 2888	·840 2156	·190 1708	·765 6236	·646 6234	·847 6867	·179 6812	·762 8094	51
10	0·643 3445	0·840 3396	1·189 9950	0·765 5768	0·646 6788	0·847 8117	1·179 5073	0·762 7624	50
11	·643 4002	·840 4637	·189 8194	·765 5300	·646 7343	·847 9367	·179 3334	·762 7154	49
12	·643 4559	·840 5878	·189 6437	·765 4832	·646 7898	·848 0617	·179 1595	·762 6683	48
13	·643 5115	·840 7119	·189 4681	·765 4364	·646 8452	·848 1867	·178 9857	·762 6213	47
14	·643 5672	·840 8361	·189 2925	·765 3896	·646 9007	·848 3118	·178 8119	·762 5742	46
15	0·643 6229	0·840 9602	1·189 1169	0·765 3428	0·646 9562	0·848 4368	1·178 6382	0·762 5272	45
16	·643 6785	·841 0844	·188 9414	·765 2960	·647 0116	·848 5619	·178 4644	·762 4802	44
17	·643 7342	·841 2085	·188 7659	·765 2492	·647 0671	·848 6870	·178 2907	·762 4331	43
18	·643 7898	·841 3327	·188 5904	·765 2024	·647 1225	·848 8121	·178 1170	·762 3860	42
19	·643 8455	·841 4569	·188 4149	·765 1556	·647 1779	·848 9372	·177 9434	·762 3390	41
20	0·643 9011	0·841 5812	1·188 2395	0·765 1087	0·647 2334	0·849 0624	1·177 7698	0·762 2919	40
21	·643 9567	·841 7054	·188 0641	·765 0619	·647 2888	·849 1875	·177 5962	·762 2448	39
22	·644 0124	·841 8296	·187 8888	·765 0151	·647 3442	·849 3127	·177 4227	·762 1978	38
23	·644 0680	·841 9539	·187 7135	·764 9682	·647 3997	·849 4379	·177 2491	·762 1507	37
24	·644 1236	·842 0782	·187 5382	·764 9214	·647 4551	·849 5631	·177 0756	·762 1036	36
25	0·644 1793	0·842 2025	1·187 3629	0·764 8746	0·647 5105	0·849 6883	1·176 9022	0·762 0565	35
26	·644 2349	·842 3268	·187 1877	·764 8277	·647 5659	·849 8135	·176 7287	·762 0094	34
27	·644 2905	·842 4511	·187 0125	·764 7809	·647 6213	·849 9388	·176 5553	·761 9623	33
28	·644 3461	·842 5755	·186 8373	·764 7340	·647 6767	·850 0640	·176 3820	·761 9152	32
29	·644 4017	·842 6998	·186 6622	·764 6871	·647 7322	·850 1893	·176 2086	·761 8681	31
30	0·644 4573	0·842 8242	1·186 4871	0·764 6403	0·647 7876	0·850 3146	1·176 0353	0·761 8210	30
31	·644 5129	·842 9486	·186 3120	·764 5934	·647 8430	·850 4399	·175 8620	·761 7739	29
32	·644 5685	·843 0730	·186 1369	·764 5465	·647 8984	·850 5653	·175 6888	·761 7268	28
33	·644 6241	·843 1974	·185 9619	·764 4997	·647 9537	·850 6906	·175 5155	·761 6797	27
34	·644 6797	·843 3218	·185 7869	·764 4528	·648 0091	·850 8159	·175 3423	·761 6326	26
35	0·644 7353	0·843 4463	1·185 6119	0·764 4059	0·648 0645	0·850 9413	1·175 1692	0·761 5854	25
36	·644 7909	·843 5708	·185 4370	·764 3590	·648 1199	·851 0667	·174 9960	·761 5383	24
37	·644 8465	·843 6952	·185 2621	·764 3121	·648 1753	·851 1921	·174 8229	·761 4912	23
38	·644 9021	·843 8197	·185 0872	·764 2652	·648 2307	·851 3175	·174 6498	·761 4440	22
39	·644 9576	·843 9442	·184 9124	·764 2183	·648 2860	·851 4430	·174 4768	·761 3969	21
40	0·645 0132	0·844 0688	1·184 7376	0·764 1714	0·648 3414	0·851 5684	1·174 3038	0·761 3497	20
41	·645 0688	·844 1933	·184 5628	·764 1245	·648 3968	·851 6939	·174 1308	·761 3026	19
42	·645 1244	·844 3179	·184 3881	·764 0776	·648 4521	·851 8194	·173 9578	·761 2554	18
43	·645 1799	·844 4424	·184 2133	·764 0307	·648 5075	·851 9449	·173 7849	·761 2083	17
44	·645 2355	·844 5670	·184 0387	·763 9838	·648 5628	·852 0704	·173 6120	·761 1611	16
45	0·645 2910	0·844 6916	1·183 8640	0·763 9368	0·648 6182	0·852 1959	1·173 4391	0·761 1140	15
46	·645 3466	·844 8162	·183 6894	·763 8899	·648 6735	·852 3214	·173 2663	·761 0668	14
47	·645 4021	·844 9409	·183 5148	·763 8430	·648 7289	852 4470	·173 0935	761 0196	13
48	·645 4577	·845 0655	·183 3402	·763 7960	·648 7842	·852 5726	·172 9207	·760 9724	12
49	·645 5132	·845 1902	·183 1657	·763 7491	·648 8396	852 6982	·172 7479	·760 9252	11
50	0·645 5688	0·845 3149	1·182 9912	0·763 7021	0·648 8949	0·852 8238	1·172 5752	0·760 8781	10
51	·645 6243	·845 4396	·182 8167	·763 6552	·648 9502	·852 9494	·172 4025	·760 8309	09
52	·645 6798	·845 5643	·182 6422	·763 6082	·649 0056	·853 0750	·172 2298	·760 7837	08
53	·645 7354	·845 6890	·182 4678	·763 5613	·649 0609	·853 2007	·172 0572	·760 7365	07
54	·645 7909	·845 8137	·182 2934	·763 5143	·649 1162	·853 3263	·171 8846	·760 6893	06
55	0·645 8464	0·845 9385	1·182 1191	0·763 4674	0·649 1715	0·853 4520	1·171 7120	0·760 6421	05
56	·645 9019	·846 0633	·181 9447	·763 4204	·649 2268	·853 5777	·171 5395	·760 5949	04
57	·645 9575	·846 1880	·181 7704	·763 3734	·649 2821	·853 7034	·171 3669	·760 5476	03
58	·646 0130	·846 3128	·181 5962	·763 3264	·649 3374	·853 8292	·171 1945	·760 5004	02
59	·646 0685	·846 4377	·181 4219	·763 2795	·649 3927	·853 9549	·171 0220	·760 4532	01
60	0·646 1240	0·846 5625	1·181 2477	0·763 2325	0·649 4480	0·854 0807	1·170 8496	0·760 4060	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	555–557	1249–1239	1742–1760	470–467	553–555	1258–1248	1724–1742	473–470	d

$3^{h}\ 19^{m}$ $3^{h}\ 18^{m}$

2ʰ 42ᵐ **2ʰ 43ᵐ**

d	553–551	1258–1267	1724–1707	472–475	551–548	1267–1277	1707–1690	474–477	d
	sin	tan	cot	cos	sin	tan	cot	cos	
s									
00	0·649 4480	0·854 0807	1·170 8496	0·760 4060	0·652 7598	0·861 6551	1·160 5571	0·757 5650	60
01	·649 5033	·854 2065	·170 6772	·760 3587	·652 8148	·861 7818	·160 3865	·757 5175	59
02	·649 5586	·854 3323	·170 5048	·760 3115	·652 8699	·861 9086	·160 2158	·757 4700	58
03	·649 6139	·854 4581	·170 3325	·760 2643	·652 9250	·862 0353	·160 0452	·757 4226	57
04	·649 6692	·854 5839	·170 1601	·760 2170	·652 9801	·862 1621	·159 8747	·757 3751	56
05	0·649 7245	0·854 7097	1·169 9879	0·760 1698	0·653 0352	0·862 2889	1·159 7041	0·757 3276	55
06	·649 7798	·854 8356	·169 8156	·760 1225	·653 0902	·862 4157	·159 5336	·757 2801	54
07	·649 8351	·854 9615	·169 6434	·760 0753	·653 1453	·862 5425	·159 3631	·757 2326	53
08	·649 8903	·855 0873	·169 4712	·760 0280	·653 2004	·862 6694	·159 1927	·757 1851	52
09	·649 9456	·855 2132	·169 2990	·759 9807	·653 2554	·862 7962	·159 0223	·757 1376	51
10	0·650 0009	0·855 3392	1·169 1269	0·759 9335	0·653 3105	0·862 9231	1·158 8519	0·757 0901	50
11	·650 0561	·855 4651	·168 9548	·759 8862	·653 3656	·863 0499	·158 6815	·757 0426	49
12	·650 1114	·855 5910	·168 7827	·759 8389	·653 4206	·863 1768	·158 5112	·756 9951	48
13	·650 1666	·855 7170	·168 6106	·759 7916	·653 4757	·863 3038	·158 3408	·756 9475	47
14	·650 2219	·855 8430	·168 4386	·759 7444	·653 5307	·863 4307	·158 1706	·756 9000	46
15	0·650 2771	0·855 9690	1·168 2666	0·759 6971	0·653 5857	0·863 5576	1·158 0003	0·756 8525	45
16	·650 3324	·856 0950	·168 0947	·759 6498	·653 6408	·863 6846	·157 8301	·756 8050	44
17	·650 3876	·856 2210	·167 9227	·759 6025	·653 6958	·863 8116	·157 6599	·756 7574	43
18	·650 4429	·856 3471	·167 7508	·759 5552	·653 7508	·863 9386	·157 4897	·756 7099	42
19	·650 4981	·856 4731	·167 5790	·759 5079	·653 8059	·864 0656	·157 3196	·756 6623	41
20	0·650 5533	0·856 5992	1·167 4071	0·759 4606	0·653 8609	0·864 1926	1·157 1495	0·756 6148	40
21	·650 6086	·856 7253	·167 2353	·759 4133	·653 9159	·864 3196	·156 9794	·756 5672	39
22	·650 6638	·856 8514	·167 0635	·759 3660	·653 9709	·864 4467	·156 8093	·756 5197	38
23	·650 7190	·856 9775	·166 8917	·759 3186	·654 0259	·864 5738	·156 6393	·756 4721	37
24	·650 7742	·857 1037	·166 7200	·759 2713	·654 0810	·864 7009	·156 4693	·756 4246	36
25	0·650 8294	0·857 2298	1·166 5483	0·759 2240	0·654 1360	0·864 8280	1·156 2993	0·756 3770	35
26	·650 8846	·857 3560	·166 3766	·759 1766	·654 1910	·864 9551	·156 1294	·756 3294	34
27	·650 9398	·857 4822	·166 2050	·759 1293	·654 2460	·865 0822	·155 9595	·756 2818	33
28	·650 9951	·857 6084	·166 0334	·759 0820	·654 3010	·865 2094	·155 7896	·756 2343	32
29	·651 0503	·857 7346	·165 8618	·759 0346	·654 3560	·865 3365	·155 6198	·756 1867	31
30	0·651 1054	0·857 8608	1·165 6903	0·758 9873	0·654 4109	0·865 4637	1·155 4499	0·756 1391	30
31	·651 1606	·857 9871	·165 5187	·758 9399	·654 4659	·865 5909	·155 2801	·756 0915	29
32	·651 2158	·858 1133	·165 3472	·758 8926	·654 5209	·865 7181	·155 1104	·756 0439	28
33	·651 2710	·858 2396	·165 1758	·758 8452	·654 5759	·865 8454	·154 9406	·755 9963	27
34	·651 3262	·858 3659	·165 0043	·758 7979	·654 6309	·865 9726	·154 7709	·755 9487	26
35	0·651 3814	0·858 4922	1·164 8329	0·758 7505	0·654 6858	0·866 0999	1·154 6012	0·755 9011	25
36	·651 4366	·858 6185	·164 6615	·758 7031	·654 7408	·866 2272	·154 4316	·755 8535	24
37	·651 4917	·858 7449	·164 4902	·758 6557	·654 7958	·866 3545	·154 2620	·755 8059	23
38	·651 5469	·858 8712	·164 3189	·758 6084	·654 8507	·866 4818	·154 0924	·755 7582	22
39	·651 6021	·858 9976	·164 1476	·758 5610	·654 9057	·866 6091	·153 9228	·755 7106	21
40	0·651 6572	0·859 1240	1·163 9763	0·758 5136	0·654 9607	0·866 7365	1·153 7532	0·755 6630	20
41	·651 7124	·859 2504	·163 8051	·758 4662	·655 0156	·866 8638	·153 5837	·755 6153	19
42	·651 7675	·859 3768	·163 6339	·758 4188	·655 0706	·866 9912	·153 4143	·755 5677	18
43	·651 8227	·859 5033	·163 4627	·758 3714	·655 1255	·867 1186	153 2448	·755 5201	17
44	·651 8778	·859 6297	·163 2916	·758 3240	·655 1804	·867 2460	·153 0754	·755 4724	16
45	0·651 9330	0·859 7562	1·163 1204	0·758 2766	0·655 2354	0·867 3734	1·152 9060	0·755 4248	15
46	·651 9881	·859 8827	·162 9493	·758 2292	·655 2903	·867 5009	·152 7366	·755 3771	14
47	·652 0433	·860 0092	·162 7783	·758 1818	·655 3452	·867 6283	·152 5673	·755 3295	13
48	·652 0984	·860 1357	·162 6073	·758 1343	655 4002	·867 7558	·152 3979	·755 2818	12
49	·652 1535	·860 2622	·162 4363	·758 0869	·655 4551	·867 8833	·152 2287	·755 2341	11
50	0·652 2087	0·860 3888	1·162 2653	0·758 0395	0·655 5100	0·868 0108	1·152 0594	0·755 1865	10
51	·652 2638	·860 5153	·162 0943	·757 9921	·655 5649	·868 1383	·151 8902	·755 1388	09
52	·652 3189	·860 6419	·161 9234	·757 9446	·655 6198	·868 2659	·151 7210	·755 0911	08
53	·652 3740	·860 7685	·161 7525	·757 8972	·655 6748	·868 3934	·151 5518	·755 0435	07
54	·652 4291	·860 8951	·161 5817	·757 8497	·655 7297	·868 5210	·151 3827	·754 9958	06
55	0·652 4843	0·861 0218	1·161 4108	0·757 8023	0·655 7846	0·868 6486	1·151 2136	0·754 9481	05
56	·652 5394	·861 1484	·161 2400	·757 7548	·655 8395	·868 7762	·151 0445	·754 9004	04
57	·652 5945	·861 2751	·161 0693	·757 7074	·655 8944	·868 9038	·150 8754	·754 8527	03
58	·652 6496	·861 4017	·160 8985	·757 6599	·655 9493	·869 0314	·150 7064	·754 8050	02
59	·652 7047	·861 5284	·160 7278	·757 6125	·656 0041	·869 1591	·150 5374	·754 7573	01
60	0·652 7598	0·861 6551	1·160 5571	0·757 5650	0·656 0590	0·869 2867	1·150 3684	0·754 7096	00
									s
	cos	cot	tan	sin	cos	cot	tan	sin	
d	551–553	1267–1258	1707–1724	475–472	548–551	1277–1267	1690–1707	477–474	d

3ʰ 17ᵐ **3ʰ 16ᵐ**

$2^{h}\ 44^{m}$ $2^{h}\ 45^{m}$

d	549–546	1277–1287	1690–1673	477–480	547–544	1286–1297	1673–1656	479–482	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·656 0590	0·869 2867	1·150 3684	0·754 7096	0·659 3458	0·876 9765	1·140 2815	0·751 8398	60
01	·656 1139	·869 4144	·150 1995	·754 6619	·659 4005	·877 1051	·140 1142	·751 7919	59
02	·656 1688	·869 5421	·150 0305	·754 6142	·659 4552	·877 2338	·139 9470	·751 7439	58
03	·656 2237	·869 6698	·149 8617	·754 5664	·659 5098	·877 3625	·139 7797	·751 6959	57
04	·656 2785	·869 7976	·149 6928	·754 5187	·659 5645	·877 4912	·139 6126	·751 6480	56
05	0·656 3334	0·869 9253	1·149 5240	0·754 4710	0·659 6191	0·877 6199	1·139 4454	0·751 6000	55
06	·656 3883	·870 0531	·149 3552	·754 4232	·659 6738	·877 7487	·139 2783	·751 5520	54
07	·656 4431	·870 1809	·149 1864	·754 3755	·659 7285	·877 8774	·139 1112	·751 5041	53
08	·656 4980	·870 3087	·149 0176	·754 3278	·659 7831	·878 0062	·138 9441	·751 4561	52
09	·656 5528	·870 4365	·148 8489	·754 2800	·659 8378	·878 1350	·138 7771	·751 4081	51
10	0·656 6077	0·870 5643	1·148 6802	0·754 2323	0·659 8924	0·878 2638	1·138 6101	0·751 3601	50
11	·656 6625	·870 6921	·148 5116	·754 1845	·659 9470	·878 3926	·138 4431	·751 3121	49
12	·656 7174	·870 8200	·148 3429	·754 1368	·660 0017	·878 5215	·138 2761	·751 2641	48
13	·656 7722	·870 9479	·148 1743	·754 0890	·660 0563	·878 6503	·138 1092	·751 2161	47
14	·656 8271	·871 0758	·148 0058	·754 0412	·660 1109	·878 7792	·137 9423	·751 1681	46
15	0·656 8819	0·871 2037	1·147 8372	0·753 9935	0·660 1656	0·878 9081	1·137 7754	0·751 1201	45
16	·656 9367	·871 3316	·147 6687	·753 9457	·660 2202	·879 0370	·137 6086	·751 0721	44
17	·656 9916	·871 4596	·147 5002	·753 8979	·660 2748	·879 1659	·137 4417	·751 0241	43
18	·657 0464	·871 5875	·147 3317	·753 8502	·660 3294	·879 2949	·137 2749	·750 9761	42
19	·657 1012	·871 7155	·147 1633	·753 8024	·660 3840	·879 4238	·137 1082	·750 9281	41
20	0·657 1560	0·871 8435	1·146 9949	0·753 7546	0·660 4386	0·879 5528	1·136 9414	0·750 8800	40
21	·657 2108	·871 9715	·146 8265	·753 7068	·660 4932	·879 6818	·136 7747	·750 8320	39
22	·657 2656	·872 0995	·146 6581	·753 6590	·660 5478	·879 8108	·136 6080	·750 7840	38
23	·657 3204	·872 2275	·146 4898	·753 6112	·660 6024	·879 9398	·136 4414	·750 7359	37
24	·657 3752	·872 3556	·146 3215	·753 5634	·660 6570	·880 0688	·136 2747	·750 6879	36
25	0·657 4300	0·872 4837	1·146 1533	0·753 5156	0·660 7116	0·880 1979	1·136 1081	0·750 6398	35
26	·657 4848	·872 6118	·145 9850	·753 4678	·660 7662	·880 3270	·135 9416	·750 5918	34
27	·657 5396	·872 7399	·145 8168	·753 4200	·660 8208	·880 4561	·135 7750	·750 5437	33
28	·657 5944	·872 8680	·145 6486	·753 3721	·660 8754	·880 5852	·135 6085	·750 4957	32
29	·657 6492	·872 9961	·145 4805	·753 3243	·660 9299	·880 7143	·135 4420	·750 4476	31
30	0·657 7040	0·873 1243	1·145 3123	0·753 2765	0·660 9845	0·880 8434	1·135 2756	0·750 3995	30
31	·657 7588	·873 2524	·145 1442	·753 2287	·661 0391	·880 9726	·135 1091	·750 3515	29
32	·657 8135	·873 3806	·144 9762	·753 1808	·661 0936	·881 1017	·134 9427	·750 3034	28
33	·657 8683	·873 5088	·144 8081	·753 1330	·661 1482	·881 2309	·134 7763	·750 2553	27
34	·657 9231	·873 6371	·144 6401	·753 0851	·661 2028	·881 3601	·134 6100	·750 2072	26
35	0·657 9778	0·873 7653	1·144 4721	0·753 0373	0·661 2573	0·881 4894	1·134 4436	0·750 1592	25
36	·658 0326	·873 8935	·144 3041	·752 9894	·661 3119	·881 6186	·134 2773	·750 1111	24
37	·658 0874	·874 0218	·144 1362	·752 9416	·661 3664	·881 7478	·134 1111	·750 0630	23
38	·658 1421	·874 1501	·143 9683	·752 8937	·661 4210	·881 8771	·133 9448	·750 0149	22
39	·658 1969	·874 2784	·143 8004	·752 8459	·661 4755	·882 0064	·133 7786	·749 9668	21
40	0·658 2516	0·874 4067	1·143 6326	0·752 7980	0·661 5300	0·882 1357	1·133 6124	0·749 9187	20
41	·658 3064	·874 5350	·143 4648	·752 7501	·661 5846	·882 2650	·133 4463	·749 8706	19
42	·658 3611	·874 6634	·143 2970	·752 7022	·661 6391	·882 3944	·133 2801	·749 8224	18
43	·658 4158	·874 7918	·143 1292	·752 6544	·661 6936	·882 5237	·133 1140	·749 7743	17
44	·658 4706	·874 9201	·142 9615	·752 6065	·661 7482	·882 6531	·132 9479	·749 7262	16
45	0·658 5253	0·875 0485	1·142 7938	0·752 5586	0·661 8027	0·882 7825	1·132 7819	0·749 6781	15
46	·658 5800	·875 1769	·142 6261	·752 5107	·661 8572	·882 9119	·132 6159	·749 6300	14
47	·658 6347	·875 3054	·142 4584	·752 4628	·661 9117	·883 0413	·132 4499	·749 5818	13
48	·658 6895	·875 4338	·142 2908	·752 4149	·661 9662	·883 1707	·132 2839	·749 5337	12
49	·658 7442	·875 5623	·142 1232	·752 3670	·662 0207	·883 3002	·132 1180	·749 4855	11
50	0·658 7989	0·875 6908	1·141 9556	0·752 3191	0·662 0752	0·883 4297	1·131 9520	0·749 4374	10
51	·658 8536	·875 8193	·141 7881	·752 2712	·662 1297	·883 5591	·131 7862	·749 3892	09
52	·658 9083	·875 9478	·141 6206	·752 2233	·662 1842	·883 6886	·131 6203	·749 3411	08
53	·658 9630	·876 0763	·141 4531	·752 1754	·662 2387	·883 8182	·131 4545	·749 2929	07
54	·659 0177	·876 2048	·141 2856	·752 1274	·662 2932	·883 9477	·131 2887	·749 2448	06
55	0·659 0724	0·876 3334	1·141 1182	0·752 0795	0·662 3477	0·884 0773	1·131 1229	0·749 1966	05
56	·659 1271	·876 4620	·140 9508	·752 0316	·662 4022	·884 2068	·130 9571	·749 1484	04
57	·659 1818	·876 5906	·140 7834	·751 9836	·662 4566	·884 3364	·130 7914	·749 1003	03
58	·659 2365	·876 7192	·140 6161	·751 9357	·662 5111	·884 4660	·130 6257	·749 0521	02
59	·659 2911	·876 8478	·140 4488	·751 8878	·662 5656	·884 5956	·130 4600	·749 0039	01
60	0·659 3458	0·876 9765	1·140 2815	0·751 8398	0·662 6200	0·884 7253	1·130 2944	0·748 9557	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	546–549	1287–1277	1673–1690	480–477	544–547	1297–1286	1656–1673	482–479	d

$3^{h}\ 15^{m}$ $3^{h}\ 14^{m}$

$2^{h}\ 46^{m}$

$2^{h}\ 47^{m}$

d	545–542	1296–1307	1656–1640	482–484	543–540	1307–1317	1640–1624	484–487	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·662 6200	0·884 7253	1·130 2944	0·748 9557	0·665 8817	0·892 5341	1·120 4053	0·746 0574	60
01	·662 6745	·884 8549	·130 1288	·748 9075	·665 9359	·892 6648	·120 2413	·746 0089	59
02	·662 7290	·884 9846	·129 9632	·748 8593	·665 9902	·892 7955	·120 0774	·745 9605	58
03	·662 7834	·885 1143	·129 7976	·748 8111	·666 0444	·892 9262	·119 9134	·745 9121	57
04	·662 8379	·885 2440	·129 6321	·748 7629	·666 0987	·893 0569	·119 7495	·745 8636	56
05	0·662 8923	0·885 3737	1·129 4666	0·748 7147	0·666 1529	0·893 1876	1·119 5856	0·745 8152	55
06	·662 9468	·885 5034	·129 3011	·748 6665	·666 2071	·893 3184	·119 4218	·745 7668	54
07	·663 0012	·885 6332	·129 1356	·748 6183	·666 2614	·893 4491	·119 2579	·745 7183	53
08	·663 0557	·885 7630	·128 9702	·748 5701	·666 3156	·893 5799	·119 0941	·745 6699	52
09	·663 1101	·885 8927	·128 8048	·748 5219	·666 3698	·893 7107	·118 9303	·745 6214	51
10	0·663 1645	0·886 0225	1·128 6395	0·748 4737	0·666 4240	0·893 8415	1·118 7666	0·745 5729	50
11	·663 2190	·886 1524	·128 4741	·748 4254	·666 4783	·893 9723	·118 6028	·745 5245	49
12	·663 2734	·886 2822	·128 3088	·748 3772	·666 5325	·894 1032	·118 4391	·745 4760	48
13	·663 3278	·886 4121	·128 1435	·748 3290	·666 5867	·894 2341	·118 2755	·745 4275	47
14	·663 3822	·886 5419	·127 9782	·748 2807	·666 6409	·894 3649	·118 1118	·745 3790	46
15	0·663 4366	0·886 6718	1·127 8130	0·748 2325	0·666 6951	0·894 4958	1·117 9482	0·745 3306	45
16	·663 4910	·886 8017	·127 6478	·748 1842	·666 7493	·894 6268	·117 7846	·745 2821	44
17	·663 5455	·886 9316	·127 4826	·748 1360	·666 8035	·894 7577	·117 6210	·745 2336	43
18	·663 5999	·887 0616	·127 3175	·748 0877	·666 8577	·894 8886	·117 4575	·745 1851	42
19	·663 6543	·887 1915	·127 1523	·748 0395	·666 9119	·895 0196	·117 2940	·745 1366	41
20	0·663 7087	0·887 3215	1·126 9872	0·747 9912	0·666 9661	0·895 1506	1·117 1305	0·745 0881	40
21	·663 7631	·887 4515	·126 8222	·747 9429	·667 0202	·895 2816	·116 9670	·745 0396	39
22	·663 8174	·887 5815	·126 6571	·747 8946	·667 0744	·895 4126	·116 8036	·744 9911	38
23	·663 8718	·887 7115	·126 4921	·747 8464	·667 1286	·895 5437	·116 6401	·744 9426	37
24	·663 9262	·887 8415	·126 3271	·747 7981	·667 1828	·895 6747	·116 4768	·744 8941	36
25	0·663 9806	0·887 9716	1·126 1621	0·747 7498	0·667 2369	0·895 8058	1·116 3134	0·744 8455	35
26	·664 0350	·888 1017	·125 9972	·747 7015	·667 2911	·895 9369	·116 1501	·744 7970	34
27	·664 0893	·888 2318	·125 8323	·747 6532	·667 3453	·896 0680	·115 9868	·744 7485	33
28	·664 1437	·888 3619	·125 6674	·747 6049	·667 3994	·896 1991	·115 8235	·744 6999	32
29	·664 1981	·888 4920	·125 5026	·747 5566	·667 4536	·896 3302	·115 6602	·744 6514	31
30	0·664 2524	0·888 6221	1·125 3377	0·747 5083	0·667 5077	0·896 4614	1·115 4970	0·744 6029	30
31	·664 3068	·888 7523	·125 1729	·747 4600	·667 5619	·896 5926	·115 3338	·744 5543	29
32	·664 3612	·888 8825	·125 0081	·747 4117	·667 6160	·896 7238	·115 1706	·744 5058	28
33	·664 4155	·889 0126	·124 8434	·747 3634	·667 6702	·896 8550	·115 0075	·744 4572	27
34	·664 4699	·889 1428	·124 6787	·747 3151	·667 7243	·896 9862	·114 8444	·744 4087	26
35	0·664 5242	0·889 2731	1·124 5140	0·747 2667	0·667 7784	0·897 1174	1·114 6813	0·744 3601	25
36	·664 5785	·889 4033	·124 3493	·747 2184	·667 8326	·897 2487	·114 5182	·744 3115	24
37	·664 6329	·889 5336	·124 1847	·747 1701	·667 8867	·897 3800	·114 3552	·744 2630	23
38	·664 6872	·889 6638	·124 0201	·747 1218	·667 9408	·897 5113	·114 1922	·744 2144	22
39	·664 7415	·889 7941	·123 8555	·747 0734	·667 9949	·897 6426	·114 0292	·744 1658	21
40	0·664 7959	0·889 9244	1·123 6909	0·747 0251	0·668 0490	0·897 7739	1·113 8662	0·744 1173	20
41	·664 8502	·890 0548	·123 5264	·746 9767	·668 1032	·897 9052	·113 7033	·744 0687	19
42	·664 9045	·890 1851	·123 3619	·746 9284	·668 1573	·898 0366	·113 5404	·744 0201	18
43	664 9588	890 3155	123 1974	·746 8800	·668 2114	·898 1680	·113 3775	·743 9715	17
44	·665 0131	·890 4458	·123 0329	·746 8317	·668 2655	·898 2994	·113 2146	·743 9229	16
45	0·665 0674	0·890 5762	1·122 8685	0·746 7833	0·668 3196	0·898 4308	1·113 0518	0·743 8743	15
46	·665 1218	·890 7066	·122 7041	·746 7349	·668 3737	·898 5622	·112 8890	·743 8257	14
47	·665 1761	·890 8371	·122 5397	·746 6866	·668 4277	·898 6937	·112 7262	·743 7771	13
48	·665 2304	·890 9675	·122 3754	·746 6382	·668 4818	·898 8251	·112 5635	·743 7285	12
49	·665 2846	·891 0980	·122 2111	·746 5898	·668 5359	·898 9566	·112 4007	·743 6799	11
50	0·665 3389	0·891 2284	1·122 0468	0·746 5414	0·668 5900	0·899 0881	1·112 2380	0·743 6312	10
51	·665 3932	·891 3589	·121 8825	·746 4930	·668 6441	·899 2196	·112 0754	·743 5826	09
52	·665 4475	·891 4894	·121 7183	·746 4446	·668 6981	·899 3512	·111 9127	·743 5340	08
53	·665 5018	·891 6200	·121 5541	·746 3962	·668 7522	·899 4827	·111 7501	·743 4854	07
54	·665 5561	·891 7505	·121 3899	·746 3478	·668 8063	·899 6143	·111 5875	·743 4367	06
55	0·665 6103	0·891 8811	1·121 2257	0·746 2994	0·668 8603	0·899 7459	1·111 4250	0·743 3881	05
56	·665 6646	·892 0116	·121 0616	·746 2510	·668 9144	·899 8775	·111 2624	·743 3394	04
57	·665 7189	·892 1422	·120 8975	·746 2026	·668 9685	·900 0091	·111 0999	·743 2908	03
58	·665 7731	·892 2729	·120 7334	·746 1542	·669 0225	·900 1407	·110 9374	·743 2421	02
59	·665 8274	·892 4035	·120 5694	·746 1058	·669 0766	·900 2724	·110 7749	·743 1935	01
60	0·665 8817	0·892 5341	1·120 4053	0·746 0574	0·669 1306	0·900 4040	1·110 6125	0·743 1448	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	542–545	1307–1296	1640–1656	484–482	540–543	1317–1307	1624–1640	487–484	d

$3^{h}\ 13^{m}$

$3^{h}\ 12^{m}$

2ʰ 48ᵐ **2ʰ 49ᵐ**

d	541–538	1317–1327	1624–1609	486–489	539–536	1327–1338	1608–1593	489–492	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·669 1306	0·900 4040	1·110 6125	0·743 1448	0·672 3668	0·908 3360	1·100 9141	0·740 2181	60
01	·669 1846	·900 5357	·110 4501	·743 0962	·672 4206	·908 4688	·100 7533	·740 1692	59
02	·669 2387	·900 6674	·110 2877	·743 0475	·672 4745	·908 6015	·100 5925	·740 1203	58
03	·669 2927	·900 7992	·110 1254	·742 9988	·672 5283	·908 7343	·100 4317	·740 0714	57
04	·669 3468	·900 9309	·109 9630	·742 9502	·672 5821	·908 8671	·100 2709	·740 0225	56
05	0·669 4008	0·901 0627	1·109 8007	0·742 9015	0·672 6359	0·908 9999	1·100 1102	0·739 9736	55
06	·669 4548	·901 1944	·109 6385	·742 8528	·672 6897	·909 1327	·099 9494	·739 9247	54
07	·669 5088	·901 3262	·109 4762	·742 8041	·672 7435	·909 2655	·099 7887	·739 8758	53
08	·669 5628	·901 4580	·109 3140	·742 7554	·672 7973	·909 3984	·099 6281	·739 8268	52
09	·669 6169	·901 5899	·109 1518	·742 7067	·672 8511	·909 5313	·099 4674	·739 7779	51
10	0·669 6709	0·901 7217	1·108 9896	0·742 6580	0·672 9049	0·909 6642	1·099 3068	0·739 7290	50
11	·669 7249	·901 8536	·108 8275	·742 6093	·672 9587	·909 7971	·099 1462	·739 6800	49
12	·669 7789	·901 9854	·108 6653	·742 5606	·673 0125	·909 9300	·098 9857	·739 6311	48
13	·669 8329	·902 1173	·108 5032	·742 5119	·673 0663	·910 0629	·098 8251	·739 5822	47
14	·669 8869	·902 2493	·108 3412	·742 4632	·673 1201	·910 1959	·098 6646	·739 5332	46
15	0·669 9409	0·902 3812	1·108 1791	0·742 4145	0·673 1739	0·910 3289	1·098 5041	0·739 4842	45
16	·669 9948	·902 5131	·108 0171	·742 3658	·673 2276	·910 4619	·098 3436	·739 4353	44
17	·670 0488	·902 6451	·107 8551	·742 3170	·673 2814	·910 5949	·098 1832	·739 3863	43
18	·670 1028	·902 7771	·107 6932	·742 2683	·673 3352	·910 7279	·098 0228	·739 3374	42
19	·670 1568	·902 9091	·107 5312	·742 2196	·673 3889	·910 8610	·097 8624	·739 2884	41
20	0·670 2108	0·903 0411	1·107 3693	0·742 1708	0·673 4427	0·910 9940	1·097 7020	0·739 2394	40
21	·670 2647	·903 1731	·107 2074	·742 1221	·673 4965	·911 1271	·097 5417	·739 1905	39
22	·670 3187	·903 3052	·107 0456	·742 0733	·673 5502	·911 2602	·097 3814	·739 1415	38
23	·670 3727	·903 4373	·106 8837	·742 0246	·673 6040	·911 3933	·097 2211	·739 0925	37
24	·670 4266	·903 5693	·106 7219	·741 9758	·673 6577	·911 5265	·097 0609	·739 0435	36
25	0·670 4806	0·903 7014	1·106 5601	0·741 9271	0·673 7115	0·911 6596	1·096 9006	0·738 9945	35
26	·670 5345	·903 8336	·106 3984	·741 8783	·673 7652	·911 7928	·096 7404	·738 9455	34
27	·670 5885	·903 9657	·106 2367	·741 8296	·673 8189	·911 9260	·096 5802	·738 8965	33
28	·670 6424	·904 0979	·106 0750	·741 7808	·673 8727	·912 0592	·096 4201	·738 8475	32
29	·670 6964	·904 2300	·105 9133	·741 7320	·673 9264	·912 1924	·096 2599	·738 7985	31
30	0·670 7503	0·904 3622	1·105 7516	0·741 6832	0·673 9801	0·912 3257	1·096 0998	0·738 7495	30
31	·670 8042	·904 4944	·105 5900	·741 6345	·674 0338	·912 4589	·095 9398	·738 7005	29
32	·670 8582	·904 6267	·105 4284	·741 5857	·674 0876	·912 5922	·095 7797	·738 6515	28
33	·670 9121	·904 7589	·105 2668	·741 5369	·674 1413	·912 7255	·095 6197	·738 6024	27
34	·670 9660	·904 8912	·105 1053	·741 4881	·674 1950	·912 8588	·095 4597	·738 5534	26
35	0·671 0199	0·905 0234	1·104 9438	0·741 4393	0·674 2487	0·912 9921	1·095 2997	0·738 5044	25
36	·671 0739	·905 1557	·104 7823	·741 3905	·674 3024	·913 1255	·095 1397	·738 4553	24
37	·671 1278	·905 2880	·104 6208	·741 3417	·674 3561	·913 2588	·094 9798	·738 4063	23
38	·671 1817	·905 4204	·104 4594	·741 2929	·674 4098	·913 3922	·094 8199	·738 3573	22
39	·671 2356	·905 5527	·104 2979	·741 2441	·674 4635	·913 5256	·094 6600	·738 3082	21
40	0·671 2895	0·905 6851	1·104 1365	0·741 1953	0·674 5172	0·913 6591	1·094 5002	0·738 2592	20
41	·671 3434	·905 8175	·103 9752	·741 1464	·674 5709	·913 7925	·094 3404	·738 2101	19
42	·671 3973	·905 9499	·103 8138	·741 0976	·674 6245	·913 9259	·094 1806	·738 1611	18
43	·671 4512	·906 0823	·103 6525	·741 0488	·674 6782	·914 0594	·094 0208	·738 1120	17
44	·671 5051	·906 2147	·103 4912	·741 0000	·674 7319	·914 1929	·093 8610	·738 0629	16
45	0·671 5590	0·906 3472	1·103 3300	0·740 9511	0·674 7856	0·914 3264	1·093 7013	0·738 0139	15
46	·671 6128	·906 4796	·103 1687	·740 9023	·674 8392	·914 4599	·093 5416	·737 9648	14
47	·671 6667	·906 6121	·103 0075	·740 8534	·674 8929	·914 5935	·093 3819	·737 9157	13
48	·671 7206	·906 7446	·102 8463	·740 8046	·674 9466	·914 7270	·093 2223	·737 8666	12
49	·671 7745	·906 8772	·102 6852	·740 7557	·675 0002	·914 8606	·093 0627	·737 8175	11
50	0·671 8283	0·907 0097	1·102 5241	0·740 7069	0·675 0539	0·914 9942	1·092 9031	0·737 7684	10
51	·671 8822	·907 1422	·102 3629	·740 6580	·675 1075	·915 1278	·092 7435	·737 7194	09
52	·671 9361	·907 2748	·102 2019	·740 6092	·675 1612	·915 2615	·092 5840	·737 6703	08
53	·671 9899	·907 4074	·102 0408	·740 5603	·675 2148	·915 3951	·092 4244	·737 6212	07
54	·672 0438	·907 5400	·101 8798	·740 5114	·675 2684	·915 5288	·092 2649	·737 5720	06
55	0·672 0976	0·907 6726	1·101 7188	0·740 4626	0·675 3221	0·915 6625	1·092 1055	0·737 5229	05
56	·672 1515	·907 8053	·101 5578	·740 4137	·675 3757	·915 7962	·091 9460	·737 4738	04
57	·672 2053	·907 9380	·101 3968	·740 3648	·675 4293	·915 9299	·091 7866	·737 4247	03
58	·672 2591	·908 0706	·101 2359	·740 3159	·675 4830	·916 0636	·091 6272	·737 3756	02
59	·672 3130	·908 2033	·101 0750	·740 2670	·675 5366	·916 1974	·091 4678	·737 3265	01
60	0·672 3668	0·908 3360	1·100 9141	0·740 2181	0·675 5902	0·916 3312	1·091 3085	0·737 2773	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	538–541	1327–1317	1609–1624	489–486	536–539	1338–1327	1593–1608	492–489	d

3ʰ 11ᵐ **3ʰ 10ᵐ**

2^{h} 50^{m} | 2^{h} 51^{m}

d	536–534	1338–1349	1593–1578	491–494	534–532	1349–1360	1578–1564	493–496	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·675 5902	0·916 3312	1·091 3085	0·737 2773	0·678 8007	0·924 3905	1·081 7939	0·734 3225	60
01	·675 6438	·916 4650	·091 1492	·737 2282	·678 8541	·924 5254	·081 6361	·734 2731	59
02	·675 6974	·916 5988	·090 9899	·737 1791	·678 9075	·924 6603	·081 4783	·734 2238	58
03	·675 7510	·916 7326	·090 8306	·737 1299	·678 9609	·924 7952	·081 3205	·734 1744	57
04	·675 8046	·916 8665	·090 6714	·737 0808	·679 0143	·924 9301	·081 1628	·734 1250	56
05	0·675 8582	0·917 0003	1·090 5122	0·737 0316	0·679 0677	0·925 0650	1·081 0051	0·734 0756	55
06	·675 9118	·917 1342	·090 3530	·736 9825	·679 1211	·925 2000	·080 8474	·734 0263	54
07	·675 9654	·917 2681	·090 1938	·736 9333	·679 1745	·925 3350	·080 6897	·733 9769	53
08	·676 0190	·917 4020	·090 0347	·736 8842	·679 2278	·925 4700	·080 5321	·733 9275	52
09	·676 0726	·917 5360	·089 8755	·736 8350	·679 2812	·925 6050	·080 3745	·733 8781	51
10	0·676 1262	0·917 6699	1·089 7165	0·736 7858	0·679 3346	0·925 7400	1·080 2169	0·733 8287	50
11	·676 1798	·917 8039	·089 5574	·736 7367	·679 3879	·925 8751	·080 0593	·733 7793	49
12	·676 2333	·917 9379	·089 3984	·736 6875	·679 4413	·926 0102	·079 9018	733 7299	48
13	·676 2869	·918 0719	·089 2393	·736 6383	·679 4947	·926 1452	·079 7442	·733 6805	47
14	·676 3405	·918 2059	·089 0803	·736 5891	·679 5480	·926 2804	·079 5868	·733 6310	46
15	0·676 3941	0·918 3399	1·088 9214	0·736 5399	0·679 6014	0·926 4155	1·079 4293	0·733 5816	45
16	·676 4476	·918 4740	·088 7624	·736 4908	·679 6547	·926 5506	·079 2718	·733 5322	44
17	·676 5012	·918 6081	·088 6035	·736 4416	·679 7081	·926 6858	·079 1144	·733 4828	43
18	·676 5547	·918 7422	·088 4446	·736 3924	·679 7614	·926 8210	·078 9570	·733 4333	42
19	·676 6083	·918 8763	·088 2858	·736 3432	·679 8147	·926 9562	·078 7997	·733 3839	41
20	0·676 6618	0·919 0104	1·088 1269	0·736 2940	0·679 8681	0·927 0914	1·078 6423	0·733 3345	40
21	·676 7154	·919 1446	·087 9681	·736 2447	·679 9214	·927 2266	·078 4850	·733 2850	39
22	·676 7689	·919 2787	·087 8093	·736 1955	·679 9747	·927 3619	·078 3277	·733 2356	38
23	·676 8224	·919 4129	·087 6506	·736 1463	·680 0280	·927 4971	·078 1704	·733 1861	37
24	·676 8760	·919 5471	·087 4918	·736 0971	·680 0813	·927 6324	·078 0132	·733 1367	36
25	0·676 9295	0·919 6814	1·087 3331	0·736 0479	0·680 1347	0·927 7677	1·077 8560	0·733 0872	35
26	·676 9830	·919 8156	·087 1744	·735 9986	·680 1880	·927 9031	·077 6988	·733 0377	34
27	·677 0365	·919 9499	·087 0158	·735 9494	·680 2413	·928 0384	·077 5416	·732 9883	33
28	·677 0901	·920 0841	·086 8571	·735 9002	·680 2946	·928 1738	·077 3845	·732 9388	32
29	·677 1436	·920 2184	·086 6985	·735 8509	·680 3479	·928 3092	·077 2273	·732 8893	31
30	0·677 1971	0·920 3527	1·086 5399	0·735 8017	0·680 4012	0·928 4446	1·077 0702	0·732 8398	30
31	·677 2506	·920 4871	·086 3814	·735 7524	·680 4545	·928 5800	·076 9132	·732 7904	29
32	·677 3041	·920 6214	·086 2228	·735 7032	·680 5078	·928 7154	·076 7561	·732 7409	28
33	·677 3576	·920 7558	·086 0643	·735 6539	·680 5610	·928 8509	·076 5991	·732 6914	27
34	·677 4111	·920 8902	·085 9058	·735 6047	·680 6143	·928 9863	·076 4421	·732 6419	26
35	0·677 4646	0·921 0246	1·085 7474	0·735 5554	0·680 6676	0·929 1218	1·076 2851	0·732 5924	25
36	·677 5181	·921 1590	·085 5889	·735 5061	·680 7209	·929 2573	·076 1282	·732 5429	24
37	·677 5716	·921 2934	·085 4305	·735 4568	·680 7741	·929 3929	·075 9712	·732 4934	23
38	·677 6250	·921 4279	·085 2721	·735 4076	·680 8274	·929 5284	·075 8143	·732 4439	22
39	·677 6785	·921 5624	·085 1138	·735 3583	·680 8807	·929 6640	·075 6575	·732 3944	21
40	0·677 7320	0·921 6969	1·084 9554	0·735 3090	0·680 9339	0·929 7996	1·075 5006	0·732 3449	20
41	·677 7855	·921 8314	·084 7971	·735 2597	·680 9872	·929 9352	·075 3438	·732 2953	19
42	·677 8389	·921 9659	·084 6388	·735 2104	·681 0404	·930 0708	·075 1870	·732 2458	18
43	·677 8924	·922 1004	·084 4806	·735 1611	·681 0937	·930 2064	·075 0302	·732 1963	17
44	·677 9459	·922 2350	·084 3223	·735 1118	·681 1469	·930 3421	·074 8734	·732 1467	16
45	0·677 9993	0·922 3696	1·084 1641	0·735 0625	0·681 2002	0·930 4778	1·074 7167	0·732 0972	15
46	·678 0528	·922 5042	·084 0059	·735 0132	·681 2534	·930 6135	·074 5600	·732 0477	14
47	·678 1062	·922 6388	·083 8478	·734 9639	·681 3066	·930 7492	·074 4033	·731 9981	13
48	·678 1597	·922 7734	·083 6896	·734 9146	·681 3599	·930 8849	·074 2467	·731 9486	12
49	·678 2131	·922 9081	·083 5315	·734 8653	·681 4131	·931 0206	·074 0900	·731 8990	11
50	0·678 2666	0·923 0428	1·083 3734	0·734 8160	0·681 4663	0·931 1564	1·073 9334	0·731 8495	10
51	·678 3200	·923 1775	·083 2154	·734 7666	·681 5195	·931 2922	·073 7769	·731 7999	09
52	·678 3734	·923 3122	·083 0573	·734 7173	·681 5728	·931 4280	·073 6203	·731 7503	08
53	·678 4268	·923 4469	·082 8993	·734 6680	·681 6260	·931 5638	·073 4638	·731 7008	07
54	·678 4803	·923 5816	·082 7413	·734 6186	·681 6792	931 6997	·073 3073	·731 6512	06
55	0·678 5337	0·923 7164	1·082 5834	0·734 5693	0·681 7324	0·931 8355	1·073 1508	0·731 6016	05
56	·678 5871	·923 8512	·082 4254	·734 5199	·681 7856	·931 9714	·072 9943	·731 5521	04
57	·678 6405	·923 9860	·082 2675	·734 4706	·681 8388	·932 1073	·072 8379	·731 5025	03
58	·678 6939	·924 1208	·082 1096	·734 4212	·681 8920	·932 2432	·072 6815	·731 4529	02
59	·678 7473	·924 2556	·081 9517	·734 3719	·681 9452	·932 3791	·072 5251	·731 4033	01
60	0·678 8007	0·924 3905	1·081 7939	0·734 3225	0·681 9984	0·932 5151	1·072 3687	0·731 3537	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	534–536	1349–1338	1578–1593	494–491	532–534	1360–1349	1564–1578	496–493	d

3^{h} 09^{m} | 3^{h} 08^{m}

$2^h\ 52^m$ $2^h\ 53^m$

d	532–529	1359–1371	1563–1549	496–499	530–527	1371–1382	1549–1535	498–501	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·681 9984	0·932 5151	1·072 3687	0·731 3537	0·685 1830	0·940 7061	1·063 0313	0·728 3710	60
01	·682 0515	·932 6511	·072 2124	·731 3041	·685 2360	·940 8432	·062 8764	·728 3211	59
02	·682 1047	·932 7870	·072 0561	·731 2545	·685 2889	·940 9803	·062 7216	·728 2713	58
03	·682 1579	·932 9230	·071 8998	·731 2049	·685 3419	·941 1174	·062 5667	·728 2215	57
04	·682 2111	·933 0591	·071 7435	·731 1553	·685 3948	·941 2545	·062 4119	·728 1716	56
05	0·682 2642	0·933 1951	1·071 5873	0·731 1057	0·685 4478	0·941 3917	1·062 2571	0·728 1218	55
06	·682 3174	·933 3312	·071 4310	·731 0561	·685 5007	·941 5289	·062 1023	·728 0719	54
07	·682 3706	·933 4673	·071 2749	·731 0064	·685 5537	·941 6661	·061 9476	·728 0221	53
08	·682 4237	·933 6034	·071 1187	·730 9568	·685 6066	·941 8033	·061 7929	·727 9722	52
09	·682 4769	·933 7395	·070 9625	·730 9072	·685 6596	·941 9405	·061 6382	·727 9224	51
10	0·682 5300	0·933 8756	1·070 8064	0·730 8575	0·685 7125	0·942 0778	1·061 4835	0·727 8725	50
11	·682 5832	·934 0118	·070 6503	·730 8079	·685 7654	·942 2150	·061 3288	·727 8226	49
12	·682 6363	·934 1479	·070 4943	·730 7583	·685 8184	·942 3523	·061 1742	·727 7728	48
13	·682 6895	·934 2841	·070 3382	·730 7086	·685 8713	·942 4896	·061 0196	·727 7229	47
14	·682 7426	·934 4203	·070 1822	·730 6590	·685 9242	·942 6270	·060 8650	·727 6730	46
15	0·682 7957	0·934 5566	1·070 0262	0·730 6093	0·685 9771	0·942 7643	1·060 7105	0·727 6231	45
16	·682 8489	·934 6928	·069 8702	·730 5597	·686 0300	·942 9017	·060 5560	·727 5732	44
17	·682 9020	·934 8291	·069 7143	·730 5100	·686 0829	·943 0391	·060 4015	·727 5233	43
18	·682 9551	·934 9654	·069 5583	·730 4603	·686 1358	·943 1765	·060 2470	·727 4734	42
19	·683 0082	·935 1017	·069 4024	·730 4107	·686 1887	·943 3139	·060 0925	·727 4235	41
20	0·683 0613	0·935 2380	1·069 2466	0·730 3610	0·686 2416	0·943 4513	1·059 9381	0·727 3736	40
21	·683 1145	·935 3743	·069 0907	·730 3113	·686 2945	·943 5888	·059 7837	·727 3237	39
22	·683 1676	·935 5107	·068 9349	·730 2616	·686 3474	·943 7263	·059 6293	·727 2738	38
23	·683 2207	·935 6471	·068 7791	·730 2120	·686 4003	·943 8638	·059 4749	·727 2239	37
24	·683 2738	·935 7834	·068 6233	·730 1623	·686 4532	·944 0013	·059 3206	·727 1740	36
25	0·683 3269	0·935 9199	1·068 4675	0·730 1126	0·686 5061	0·944 1388	1·059 1663	0·727 1241	35
26	·683 3800	·936 0563	·068 3118	·730 0629	·686 5589	·944 2764	·059 0120	·727 0741	34
27	·683 4331	·936 1927	·068 1561	·730 0132	·686 6118	·944 4140	·058 8577	·727 0242	33
28	·683 4861	·936 3292	·068 0004	·729 9635	·686 6647	·944 5516	·058 7035	·726 9743	32
29	·683 5392	·936 4657	·067 8448	·729 9138	·686 7176	·944 6892	·058 5492	·726 9243	31
30	0·683 5923	0·936 6022	1·067 6891	0·729 8641	0·686 7704	0·944 8268	1·058 3950	0·726 8744	30
31	·683 6454	·936 7387	·067 5335	·729 8144	·686 8233	·944 9645	·058 2409	·726 8245	29
32	·683 6984	·936 8753	·067 3779	·729 7646	·686 8761	·945 1021	·058 0867	·726 7745	28
33	·683 7515	·937 0118	·067 2224	·729 7149	·686 9290	·945 2398	·057 9326	·726 7246	27
34	·683 8046	·937 1484	·067 0668	·729 6652	·686 9818	·945 3775	·057 7785	·726 6746	26
35	0·683 8576	0·937 2850	1·066 9113	0·729 6155	0·687 0347	0·945 5152	1·057 6244	0·726 6246	25
36	·683 9107	·937 4216	·066 7558	·729 5657	·687 0875	·945 6530	·057 4704	·726 5747	24
37	·683 9638	·937 5583	·066 6004	·729 5160	·687 1403	·945 7908	·057 3163	·726 5247	23
38	·684 0168	·937 6949	·066 4449	·729 4663	·687 1932	·945 9285	·057 1623	·726 4747	22
39	·684 0699	·937 8316	·066 2895	·729 4165	·687 2460	·946 0663	·057 0083	·726 4248	21
40	0·684 1229	0·937 9683	1·066 1341	0·729 3668	0·687 2988	0·946 2042	1·056 8544	0·726 3748	20
41	·684 1759	·938 1050	·065 9787	·729 3170	·687 3517	·946 3420	·056 7004	·726 3248	19
42	·684 2290	·938 2417	·065 8234	·729 2672	·687 4045	·946 4799	·056 5465	·726 2748	18
43	·684 2820	·938 3785	·065 6681	·729 2175	·687 4573	·946 6177	·056 3926	·726 2248	17
44	·684 3350	·938 5153	·065 5128	·729 1677	·687 5101	·946 7556	·056 2388	·726 1748	16
45	0·684 3881	0·938 6520	1·065 3575	0·729 1180	0·687 5629	0·946 8935	1·056 0849	0·726 1248	15
46	·684 4411	·938 7888	·065 2023	·729 0682	·687 6157	·947 0315	·055 9311	·726 0748	14
47	·684 4941	·938 9257	·065 0470	·729 0184	·687 6685	·947 1694	·055 7773	·726 0248	13
48	·684 5471	·939 0625	·064 8918	·728 9686	·687 7213	·947 3074	·055 6235	·725 9748	12
49	·684 6001	·939 1994	·064 7367	·728 9188	·687 7741	·947 4454	·055 4698	·725 9248	11
50	0·684 6531	0·939 3362	1·064 5815	0·728 8691	0·687 8269	0·947 5834	1·055 3161	0·725 8748	10
51	·684 7061	·939 4731	·064 4264	·728 8193	·687 8797	·947 7214	·055 1624	·725 8247	09
52	·684 7591	·939 6101	·064 2713	·728 7695	·687 9325	·947 8595	·055 0087	·725 7747	08
53	·684 8121	·939 7470	·064 1162	·728 7197	·687 9852	·947 9976	·054 8550	·725 7247	07
54	·684 8651	·939 8839	·063 9611	·728 6699	·688 0380	·948 1356	·054 7014	·725 6747	06
55	0·684 9181	0·940 0209	1·063 8061	0·728 6201	0·688 0908	0·948 2738	1·054 5478	0·725 6246	05
56	·684 9711	·940 1579	·063 6511	·728 5703	·688 1435	·948 4119	·054 3942	·725 5746	04
57	·685 0241	·940 2949	·063 4961	·728 5204	·688 1963	·948 5500	·054 2407	·725 5245	03
58	·685 0770	·940 4320	·063 3412	·728 4706	·688 2491	·948 6882	·054 0871	·725 4745	02
59	·685 1300	·940 5690	·063 1862	·728 4208	·688 3018	·948 8264	·053 9336	·725 4244	01
60	0·685 1830	0·940 7061	1·063 0313	0·728 3710	0·688 3546	0·948 9646	1·053 7801	0·725 3744	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	529–532	1371–1359	1549–1563	499–496	527–530	1382–1371	1535–1549	501–498	d

$3^h\ 07^m$ $3^h\ 06^m$

2^h 54^m 2^h 55^m

d	528–525	1382–1394	1535–1521	500–503	526–523	1394–1406	1521–1507	503–505	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·688 3546	0·948 9646	1·053 7801	0·725 3744	0·691 5131	0·957 2917	1·044 6136	0·722 3640	60
01	·688 4073	·949 1028	·053 6267	·725 3243	·691 5656	·957 4311	·044 4616	·722 3137	59
02	·688 4601	·949 2410	·053 4732	·725 2742	·691 6181	·957 5705	·044 3095	·722 2634	58
03	·688 5128	·949 3793	·053 3198	·725 2242	·691 6706	·957 7099	·044 1575	·722 2131	57
04	·688 5655	·949 5176	·053 1664	·725 1741	·691 7232	·957 8494	·044 0055	·722 1628	56
05	0·688 6183	0·949 6559	1·053 0130	0·725 1240	0·691 7757	0·957 9888	1·043 8535	0·722 1125	55
06	·688 6710	·949 7942	·052 8597	·725 0740	·691 8282	·958 1283	·043 7016	·722 0622	54
07	·688 7237	·949 9325	·052 7064	·725 0239	·691 8807	·958 2678	·043 5497	·722 0119	53
08	·688 7765	·950 0709	·052 5531	·724 9738	·691 9332	·958 4073	·043 3977	·721 9615	52
09	·688 8292	·950 2092	·052 3998	·724 9237	·691 9857	·958 5468	·043 2459	·721 9112	51
10	0·688 8819	0·950 3476	1·052 2465	0·724 8736	0·692 0382	0·958 6864	1·043 0940	0·721 8609	50
11	·688 9346	·950 4860	·052 0933	·724 8235	·692 0907	·958 8259	·042 9422	·721 8106	49
12	·688 9873	·950 6245	·051 9401	·724 7734	·692 1432	·958 9655	·042 7904	·721 7602	48
13	·689 0400	·950 7629	·051 7869	·724 7233	·692 1957	·959 1051	·042 6386	·721 7099	47
14	·689 0927	·950 9014	·051 6338	·724 6732	·692 2481	·959 2448	·042 4868	·721 6596	46
15	0·689 1454	0·951 0399	1·051 4806	0·724 6231	0·692 3006	0·959 3844	1·042 3351	0·721 6092	45
16	·689 1981	·951 1784	·051 3275	·724 5729	·692 3531	·959 5241	·042 1833	·721 5589	44
17	·689 2508	·951 3169	·051 1744	·724 5228	·692 4056	·959 6638	·042 0316	·721 5085	43
18	·689 3035	·951 4555	·051 0214	·724 4727	·692 4580	·959 8035	·041 8800	·721 4582	42
19	·689 3562	·951 5940	·050 8683	·724 4226	·692 5105	·959 9432	·041 7283	·721 4078	41
20	0·689 4089	0·951 7326	1·050 7153	0·724 3724	0·692 5630	0·960 0829	1·041 5767	0·721 3574	40
21	·689 4615	·951 8712	·050 5623	·724 3223	·692 6154	·960 2227	·041 4251	·721 3071	39
22	·689 5142	·952 0098	·050 4093	·724 2722	·692 6679	·960 3625	·041 2735	·721 2567	38
23	·689 5669	·952 1485	·050 2564	·724 2220	·692 7203	·960 5023	·041 1219	·721 2063	37
24	·689 6195	·952 2871	·050 1034	·724 1719	·692 7728	·960 6421	·040 9704	·721 1559	36
25	0·689 6722	0·952 4258	1·049 9505	0·724 1217	0·692 8252	0·960 7819	1·040 8189	0·721 1056	35
26	·689 7249	·952 5645	·049 7977	·724 0716	·692 8776	·960 9218	·040 6674	·721 0552	34
27	·689 7775	·952 7032	·049 6448	·724 0214	·692 9301	·961 0617	·040 5159	·721 0048	33
28	·689 8302	·952 8420	·049 4920	·723 9712	·692 9825	·961 2016	·040 3645	·720 9544	32
29	·689 8828	·952 9807	·049 3392	·723 9211	·693 0349	·961 3415	·040 2131	·720 9040	31
30	0·689 9355	0·953 1195	1·049 1864	0·723 8709	0·693 0874	0·961 4815	1·040 0617	0·720 8536	30
31	·689 9881	·953 2583	·049 0336	·723 8207	·693 1398	·961 6214	·039 9103	·720 8032	29
32	·690 0407	·953 3971	·048 8809	·723 7705	·693 1922	·961 7614	·039 7589	·720 7528	28
33	·690 0934	·953 5359	·048 7282	·723 7204	·693 2446	·961 9014	·039 6076	·720 7024	27
34	·690 1460	·953 6748	·048 5755	·723 6702	·693 2970	·962 0414	·039 4563	·720 6520	26
35	0·690 1986	0·953 8137	1·048 4228	0·723 6200	0·693 3494	0·962 1814	1·039 3050	0·720 6015	25
36	·690 2512	·953 9526	·048 2702	·723 5698	·693 4018	·962 3215	·039 1538	·720 5511	24
37	·690 3039	·954 0915	·048 1175	·723 5196	·693 4542	·962 4616	·039 0025	·720 5007	2
38	·690 3565	·954 2304	·047 9649	·723 4694	·693 5066	·962 6017	·038 8513	·720 4503	
39	·690 4091	·954 3693	·047 8124	·723 4192	·693 5590	·962 7418	·038 7001	·720 3998	
40	0·690 4617	0·954 5083	1·047 6598	0·723 3690	0·693 6114	0·962 8819	1·038 5489	0·720 3494	
41	·690 5143	·954 6473	·047 5073	·723 3187	·693 6638	·963 0221	·038 3978	·720 2989	
42	·690 5669	·954 7863	·047 3548	·723 2685	·693 7162	·963 1623	·038 2467	·720 2485	
43	·690 6195	·954 9253	·047 2023	·723 2183	·693 7685	·963 3025	·038 0956	·720 1980	
44	·690 6721	·955 0644	·047 0498	·723 1681	·693 8209	·963 4427	·037 9445	·720 1476	
45	0·690 7247	0·955 2034	1·046 8974	0·723 1179	0·693 8733	0·963 5829	1·037 7934	0·720 0971	1
46	·690 7773	·955 3425	·046 7450	·723 0676	·693 9256	·963 7232	·037 6424	·720 0467	14
47	·690 8298	·955 4816	·046 5926	·723 0174	·693 9780	·963 8634	·037 4914	·719 9962	13
48	·690 8824	·955 6208	·046 4402	·722 9671	·694 0304	·964 0037	·037 3404	·719 9457	12
49	·690 9350	·955 7599	·046 2879	·722 9169	·694 0827	·964 1440	·037 1894	·719 8953	11
50	0·690 9876	0·955 8991	1·046 1356	0·722 8667	0·694 1351	0·964 2844	1·037 0385	0·719 8448	10
51	·691 0401	·956 0382	·045 9833	·722 8164	·694 1874	·964 4247	·036 8876	·719 7943	09
52	·691 0927	·956 1774	·045 8310	·722 7661	·694 2398	·964 5651	·036 7367	·719 7438	08
53	·691 1452	·956 3167	·045 6787	·722 7159	·694 2921	·964 7055	·036 5858	·719 6933	07
54	·691 1978	·956 4559	·045 5265	·722 6656	·694 3444	·964 8459	·036 4349	·719 6428	06
55	0·691 2504	0·956 5952	1·045 3743	0·722 6154	0·694 3968	0·964 9863	1·036 2841	0·719 5923	05
56	·691 3029	·956 7344	·045 2221	·722 5651	·694 4491	·965 1268	·036 1333	·719 5418	04
57	·691 3554	·956 8737	·045 0700	·722 5148	·694 5014	·965 2672	·035 9825	·719 4913	03
58	·691 4080	·957 0131	·044 9178	·722 4645	·694 5537	·965 4077	·035 8318	·719 4408	02
59	·691 4605	·957 1524	·044 7657	·722 4142	·694 6061	·965 5482	·035 6810	·719 3903	01
60	0·691 5131	0·957 2917	1·044 6136	0·722 3640	0·694 6584	0·965 6888	1·035 5303	0·719 3398	00
									s
	cos	cot	tan	sin	cos	cot	tan	sin	
d	525–528	1394–1382	1521–1535	503–500	523–526	1406–1394	1507–1521	505–503	d

3^h 05^m 3^h 04^m

$2^h\ 56^m$ $2^h\ 57^m$

d	523–521	1405–1418	1507–1494	505–508	521–518	1417–1430	1493–1480	507–510	d
s	sin	tan	cot	cos	sin	tan	cot	cos	
00	0·694 6584	0·965 6888	1·035 5303	0·719 3398	0·697 7905	0·974 1569	1·026 5287	0·716 3019	60
01	·694 7107	·965 8293	·035 3796	·719 2893	·697 8425	·974 2986	·026 3794	·716 2512	59
02	·694 7630	·965 9699	·035 2290	·719 2388	·697 8946	·974 4404	·026 2301	·716 2004	58
03	·694 8153	·966 1105	·035 0783	·719 1882	·697 9467	·974 5822	·026 0808	·716 1497	57
04	·694 8676	·966 2511	·034 9277	·719 1377	·697 9988	·974 7240	·025 9315	·716 0989	56
05	0·694 9199	0·966 3917	1·034 7771	0·719 0872	0·698 0509	0·974 8658	1·025 7822	0·716 0482	55
06	·694 9722	·966 5324	·034 6265	·719 0366	·698 1029	·975 0076	·025 6330	·715 9974	54
07	·695 0245	·966 6730	·034 4759	·718 9861	·698 1550	·975 1495	·025 4838	·715 9466	53
08	·695 0767	·966 8137	·034 3254	·718 9355	·698 2071	·975 2914	·025 3346	·715 8959	52
09	·695 1290	·966 9544	·034 1749	·718 8850	·698 2591	·975 4333	·025 1854	·715 8451	51
10	0·695 1813	0·967 0952	1·034 0244	0·718 8344	0·698 3112	0·975 5752	1·025 0363	0·715 7943	50
11	·695 2336	·967 2359	·033 8739	·718 7839	·698 3632	·975 7172	·024 8872	·715 7435	49
12	·695 2858	·967 3767	·033 7235	·718 7333	·698 4153	·975 8591	·024 7381	·715 6927	48
13	·695 3381	·967 5175	·033 5731	·718 6828	·698 4673	·976 0011	·024 5890	·715 6419	47
14	·695 3904	·967 6583	·033 4227	·718 6322	·698 5194	·976 1431	·024 4399	·715 5911	46
15	0·695 4426	0·967 7991	1·033 2723	0·718 5816	0·698 5714	0·976 2851	1·024 2909	0·715 5403	45
16	·695 4949	·967 9399	·033 1220	·718 5310	·698 6234	·976 4272	·024 1419	·715 4895	44
17	·695 5471	·968 0808	·032 9716	·718 4805	·698 6755	·976 5693	·023 9929	·715 4387	43
18	·695 5994	·968 2217	·032 8213	·718 4299	·698 7275	·976 7113	·023 8440	·715 3879	42
19	·695 6516	·968 3626	·032 6710	·718 3793	·698 7795	·976 8534	·023 6950	·715 3371	41
20	0·695 7039	0·968 5035	1·032 5208	0·718 3287	0·698 8315	0·976 9956	1·023 5461	0·715 2863	40
21	·695 7561	·968 6445	·032 3705	·718 2781	·698 8836	·977 1377	·023 3972	·715 2355	39
22	·695 8083	·968 7854	·032 2203	·718 2275	·698 9356	·977 2799	·023 2483	·715 1846	38
23	·695 8606	·968 9264	·032 0701	·718 1769	·698 9876	·977 4221	·023 0995	·715 1338	37
24	·695 9128	·969 0674	·031 9199	·718 1263	·699 0396	·977 5643	·022 9506	·715 0830	36
25	0·695 9650	0·969 2084	1·031 7698	0·718 0757	0·699 0916	0·977 7065	1·022 8018	0·715 0321	35
26	·696 0172	·969 3495	·031 6197	·718 0251	·699 1436	·977 8488	·022 6530	·714 9813	34
27	·696 0695	·969 4906	·031 4696	·717 9745	·699 1956	·977 9910	·022 5043	·714 9305	33
28	·696 1217	·969 6316	·031 3195	·717 9238	·699 2476	·978 1333	·022 3555	·714 8796	32
29	·696 1739	·969 7727	·031 1694	·717 8732	·699 2995	·978 2756	·022 2068	·714 8288	31
30	0·696 2261	0·969 9139	1·031 0194	0·717 8226	0·699 3515	0·978 4180	1·022 0581	0·714 7779	30
31	·696 2783	·970 0550	·030 8694	·717 7719	·699 4035	·978 5603	·021 9094	·714 7270	29
32	·696 3305	·970 1962	·030 7194	·717 7213	·699 4555	·978 7027	·021 7608	·714 6762	28
33	·696 3827	·970 3374	·030 5694	·717 6707	·699 5075	·978 8451	·021 6121	·714 6253	27
34	·696 4348	·970 4786	·030 4195	·717 6200	·699 5594	·978 9875	·021 4635	·714 5744	26
35	0·696 4870	0·970 6198	1·030 2695	0·717 5694	0·699 6114	0·979 1299	1·021 3149	0·714 5236	25
36	·696 5392	·970 7610	·030 1196	·717 5187	·699 6633	·979 2724	·021 1664	·714 4727	24
37	·696 5914	·970 9023	·029 9698	·717 4681	·699 7153	·979 4148	·021 0178	·714 4218	23
38	·696 6436	·971 0436	·029 8199	·717 4174	·699 7672	·979 5573	·020 8693	·714 3709	22
39	·696 6957	·971 1849	·029 6701	·717 3667	·699 8192	·979 6998	·020 7208	·714 3200	21
40	0·696 7479	0·971 3262	1·029 5203	0·717 3161	0·699 8711	0·979 8424	1·020 5723	0·714 2691	20
41	·696 8001	·971 4675	·029 3705	·717 2654	·699 9231	·979 9849	·020 4239	·714 2182	19
42	·696 8522	·971 6089	·029 2207	·717 2147	·699 9750	·980 1275	·020 2754	·714 1673	18
43	·696 9044	·971 7503	·029 0710	·717 1641	·700 0270	·980 2701	·020 1270	·714 1164	17
44	·696 9565	·971 8917	·028 9212	·717 1134	·700 0789	·980 4127	·019 9786	·714 0655	16
45	0·697 0087	0·972 0331	1·028 7715	0·717 0627	0·700 1308	0·980 5553	1·019 8303	0·714 0146	15
46	·697 0608	·972 1746	·028 6219	·717 0120	·700 1827	·980 6980	·019 6819	·713 9637	14
47	·697 1130	·972 3160	·028 4722	·716 9613	·700 2347	·980 8406	·019 5336	·713 9128	13
48	·697 1651	·972 4575	·028 3226	·716 9106	·700 2866	·980 9833	·019 3853	·713 8618	12
49	·697 2172	·972 5990	·028 1730	·716 8599	·700 3385	·981 1261	·019 2370	·713 8109	11
50	0·697 2694	0·972 7405	1·028 0234	0·716 8092	0·700 3904	0·981 2688	1·019 0888	0·713 7600	10
51	·697 3215	·972 8821	·027 8738	·716 7585	·700 4423	·981 4115	·018 9405	·713 7090	09
52	·697 3736	·973 0236	·027 7243	·716 7078	·700 4942	·981 5543	·018 7923	·713 6581	08
53	·697 4257	·973 1652	·027 5747	·716 6571	·700 5461	·981 6971	·018 6441	·713 6072	07
54	·697 4778	·973 3068	·027 4252	·716 6063	·700 5980	·981 8399	·018 4960	·713 5562	06
55	0·697 5300	0·973 4485	1·027 2758	0·716 5556	0·700 6499	0·981 9828	1·018 3478	0·713 5053	05
56	·697 5821	·973 5901	·027 1263	·716 5049	·700 7018	·982 1256	·018 1997	·713 4543	04
57	·697 6342	·973 7318	·026 9769	·716 4542	·700 7536	·982 2685	·018 0516	·713 4033	03
58	·697 6863	·973 8734	·026 8275	·716 4034	·700 8055	·982 4114	·017 9035	·713 3524	02
59	·697 7384	·974 0151	·026 6781	·716 3527	·700 8574	·982 5543	·017 7554	·713 3014	01
60	0·697 7905	0·974 1569	1·026 5287	0·716 3019	0·700 9093	0·982 6973	1·017 6074	0·713 2504	00
	cos	cot	tan	sin	cos	cot	tan	sin	s
d	521–523	1418–1405	1494–1507	508–505	518–521	1430–1417	1480–1493	510–507	d

$3^h\ 03^m$ $3^h\ 02^m$

$2^h\ 58^m$ $2^h\ 59^m$

d	519–516	1429–1442	1480–1467	·509–512	517–514	1442–1454	1467–1454	512–514	d
	sin	tan	cot	cos	sin	tan	cot	cos	
s									
00	0·700 9093	0·982 6973	1·017 6074	0·713 2504	0·704 0147	0·991 3112	1·008 7649	0·710 1854	60
01	·700 9611	·982 8402	·017 4594	·713 1995	·704 0664	·991 4554	·008 6182	·710 1342	59
02	·701 0130	·982 9832	·017 3114	·713 1485	·704 1180	·991 5996	·008 4715	·710 0830	58
03	·701 0649	·983 1262	·017 1634	·713 0975	·704 1696	·991 7439	·008 3249	·710 0318	57
04	·701 1167	·983 2692	·017 0155	·713 0465	·704 2213	·991 8881	·008 1782	·709 9806	56
05	0·701 1686	0·983 4123	1·016 8675	0·712 9955	0·704 2729	0·992 0324	1·008 0316	0·709 9293	55
06	·701 2204	·983 5553	·016 7196	·712 9446	·704 3245	·992 1767	·007 8850	·709 8781	54
07	·701 2723	·983 6984	·016 5717	·712 8936	·704 3762	·992 3210	·007 7384	·709 8269	53
08	·701 3241	·983 8415	·016 4239	·712 8426	·704 4278	·992 4654	·007 5918	·709 7757	52
09	·701 3759	·983 9846	·016 2760	·712 7916	·704 4794	·992 6097	·007 4453	·709 7244	51
10	0·701 4278	0·984 1278	1·016 1282	0·712 7405	0·704 5310	0·992 7541	1·007 2988	0·709 6732	50
11	·701 4796	·984 2709	·015 9804	·712 6895	·704 5826	·992 8985	·007 1523	·709 6220	49
12	·701 5314	·984 4141	·015 8326	·712 6385	·704 6342	·993 0429	·007 0058	·709 5707	48
13	·701 5832	·984 5573	·015 6849	·712 5875	·704 6858	·993 1874	·006 8593	·709 5195	47
14	·701 6351	·984 7006	·015 5372	·712 5365	·704 7374	·993 3319	·006 7129	·709 4682	46
15	0·701 6869	0·984 8438	1·015 3894	0·712 4855	0·704 7890	0·993 4763	1·006 5665	0·709 4170	45
16	·701 7387	·984 9871	·015 2418	·712 4344	·704 8406	·993 6208	·006 4201	·709 3657	44
17	·701 7905	·985 1304	·015 0941	·712 3834	·704 8922	·993 7654	·006 2737	·709 3145	43
18	·701 8423	·985 2737	·014 9464	·712 3324	·704 9438	·993 9099	·006 1274	·709 2632	42
19	·701 8941	·985 4170	·014 7988	·712 2813	·704 9953	·994 0545	·005 9811	·709 2119	41
20	0·701 9459	0·985 5603	1·014 6512	0·712 2303	0·705 0469	0·994 1991	1·005 8348	0·709 1607	40
21	·701 9977	·985 7037	·014 5036	·712 1792	·705 0985	·994 3437	·005 6885	·709 1094	39
22	·702 0495	·985 8471	·014 3561	·712 1282	·705 1500	·994 4883	·005 5422	·709 0581	38
23	·702 1013	·985 9905	·014 2085	·712 0771	·705 2016	·994 6330	·005 3960	·709 0068	37
24	·702 1531	·986 1339	·014 0610	·712 0260	·705 2532	·994 7777	·005 2497	·708 9556	36
25	0·702 2048	0·986 2774	1·013 9135	0·711 9750	0·705 3047	0·994 9224	1·005 1035	0·708 9043	35
26	·702 2566	·986 4209	·013 7661	·711 9239	·705 3563	·995 0671	·004 9574	·708 8530	34
27	·702 3084	·986 5644	·013 6186	·711 8728	·705 4078	·995 2118	·004 8112	·708 8017	33
28	·702 3601	·986 7079	·013 4712	·711 8218	·705 4594	·995 3566	·004 6651	·708 7504	32
29	·702 4119	·986 8514	·013 3238	·711 7707	·705 5109	·995 5014	·004 5190	·708 6991	31
30	0·702 4637	0·986 9950	1·013 1764	0·711 7196	0·705 5624	0·995 6462	1·004 3729	0·708 6478	30
31	·702 5154	·987 1385	·013 0290	·711 6685	·705 6140	·995 7910	·004 2268	·708 5965	29
32	·702 5672	·987 2821	·012 8817	·711 6174	·705 6655	·995 9358	·004 0807	·708 5451	28
33	·702 6189	·987 4258	·012 7344	·711 5663	·705 7170	·996 0807	·003 9347	·708 4938	27
34	·702 6707	·987 5694	·012 5871	·711 5152	·705 7685	·996 2256	·003 7887	·708 4425	26
35	0·702 7224	0·987 7130	1·012 4398	0·711 4641	0·705 8201	0·996 3705	1·003 6427	0·708 3912	25
36	·702 7741	·987 8567	·012 2925	·711 4130	·705 8716	·996 5154	·003 4968	·708 3398	24
37	·702 8259	·988 0004	·012 1453	·711 3619	·705 9231	·996 6604	·003 3508	·708 2885	23
38	·702 8776	·988 1441	·011 9981	·711 3108	·705 9746	·996 8053	·003 2049	·708 2372	22
39	·702 9293	·988 2879	·011 8509	·711 2597	·706 0261	·996 9503	·003 0590	·708 1858	21
40	0·702 9811	0·988 4316	1·011 7038	0·711 2086	0·706 0776	0·997 0953	1·002 9131	0·708 1345	20
41	·703 0328	·988 5754	·011 5566	·711 1574	·706 1291	·997 2404	·002 7673	·708 0831	19
42	·703 0845	·988 7192	·011 4095	·711 1063	·706 1806	·997 3854	·002 6214	·708 0318	18
43	·703 1362	·988 8631	·011 2624	·711 0552	·706 2321	·997 5305	·002 4756	·707 9804	17
44	·703 1879	·989 0069	·011 1153	·711 0041	·706 2835	·997 6756	·002 3298	·707 9291	16
45	0·703 2396	0·989 1508	1·010 9682	0·710 9529	0·706 3350	0·997 8207	1·002 1840	0·707 8777	15
46	·703 2913	·989 2946	·010 8212	·710 9018	·706 3865	·997 9659	·002 0383	·707 8263	14
47	·703 3430	·989 4385	·010 6742	·710 8506	·706 4380	·998 1110	·001 8926	·707 7750	13
48	·703 3947	·989 5825	·010 5272	·710 7995	·706 4894	·998 2562	·001 7469	·707 7236	12
49	·703 4464	·989 7264	·010 3802	·710 7483	·706 5409	·998 4014	·001 6012	·707 6722	11
50	0·703 4981	0·989 8704	1·010 2333	0·710 6972	0·706 5924	0·998 5466	1·001 4555	0·707 6208	10
51	·703 5498	·990 0144	·010 0863	·710 6460	·706 6438	·998 6919	·001 3099	·707 5694	09
52	·703 6014	·990 1584	·009 9394	·710 5948	·706 6953	·998 8371	·001 1642	·707 5180	08
53	·703 6531	·990 3024	·009 7925	·710 5437	·706 7467	·998 9824	·001 0186	·707 4666	07
54	·703 7048	·990 4465	·009 6457	·710 4925	·706 7982	·999 1277	·000 8730	·707 4152	06
55	0·703 7564	0·990 5905	1·009 4988	0·710 4413	0·706 8496	0·999 2730	1·000 7275	0·707 3638	05
56	·703 8081	·990 7346	·009 3520	·710 3901	·706 9011	·999 4184	·000 5819	·707 3124	04
57	·703 8598	·990 8787	·009 2052	·710 3390	·706 9525	·999 5638	·000 4364	·707 2610	03
58	·703 9114	·991 0229	·009 0584	·710 2878	·707 0039	·999 7092	·000 2909	·707 2096	02
59	·703 9631	·991 1670	·008 9117	·710 2366	·707 0554	0·999 8546	·000 1455	·707 1582	01
60	0·704 0147	0·991 3112	1·008 7649	0·710 1854	0·707 1068	1·000 0000	1·000 0000	0·707 1068	00
									s
	cos	cot	tan	sin	cos	cot	tan	sin	
d	516–519	1442–1429	1467–1480	512–509	514–517	1454–1442	1454–1467	514–512	d

$3^h\ 01^m$ $3^h\ 00^m$

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APPENDIX D

LIST OF RADIO TRANSMITTING STATIONS AND MONITORING OBSERVATORIES

This appendix contains a list of the most frequently used radio time signal transmitting stations and a list of the monitoring observatories. All of the radio time signal stations that transmit a signal of scientific quality are not listed, nor are all of the monitoring observatories. However, a sufficient number of stations are listed to allow a time signal of scientific quality to be received almost anywhere in the world.

This list contains only the call signs, frequencies, locations and positions of selected stations. For the latest and most up to date information on frequencies and characteristics of all transmitting stations, see the latest B.I.H. Annual Report. For a graphic representation of selected transmitting stations characteristics contact U.S. Army Topographic Command, 6500 Brooks Lane, Washington, D.C. 20315.

RADIO TRANSMITTING STATIONS

Call Signs	Location and Position	Frequency MC
CHU	Ottawa, Canada N 45° 18' W 75° 45'	3.330 7.335 14.670
HBG	Prangins, Switzerland N 46° 24' E 06° 15'	0.075
JJY	Koganei, Japan N 35° 42' E 139° 31'	2.5 5.0 10.0 15.0
LOL1	Buenos-Aires Argentina S 34° 27' W 58° 21'	5.0 10.0 15.0
MSF	Rugby, United Kingdom N 52° 22' W 01° 11'	2.5 5.0 10.0
VNG	Lyndhurst, Australia S 38° 00' E 145° 02'	4.5 7.5 12.0
WWV	Fort Collins, Colorado United States N 40° 41' W 105° 02'	2.5 5.0 10.0 15.0 20.0 25.0

Call Signs	Location and Position	Frequency MC
WWVH	Maui, Hawaii United States N 20° 46' W 156° 28'	2.5 5.0 10.0 15.0
ZUO	Olifantsfontein, South Africa S 25° 58' E 28° 04'	5.0
	Johannesburg, South Africa S 26° 11' E 28° 04'	10.0
BPV	Shanghai, China N 31° 12' E 121° 26'	5.0 10.0 15.0

MONITORING OBSERVATORIES

Observatory	Location	Instrument*	Latitude		Longitude	
			°	'	h	m
Buenos-Aires	Argentina	MT	S 34	34	W 03	54
Hamburg	W. Germany	PZT	N 53	36	E 00	40
Herstmonceux	England	PZT	N 50	52	E 00	01
Le Cap	S. Africa	Astro	S 33	56	E 01	14
Milan	Italy	ZT	N 45	28	E 00	37
Mizusawa	Japan	PZT	N 39	08	E 09	25
Mount Stromlo	Australia	PZT	S 35	19	E 09	56
Neuchatel	Switzerland	PZT	N 47	00	E 00	28
Ottawa	Canada	PZT	N 45	24	W 05	03
Paris	France	Astro	N 48	50	E 00	09
Prague	Czechoslovakia	MT	N 50	04	E 00	58
Quito	Ecuador	Astro	S 00	14	W 05	14
Richmond	United States	PZT	N 25	37	W 05	22
Rio de Janeiro	Brazil	MT	S 22	54	W 02	53
Santiago	Chile	Astro	S 33	24	W 04	42
Tokyo	Japan	PZT	N 35	40	E 09	18
Washington, DC	United States	PZT	N 38	55	W 05	08

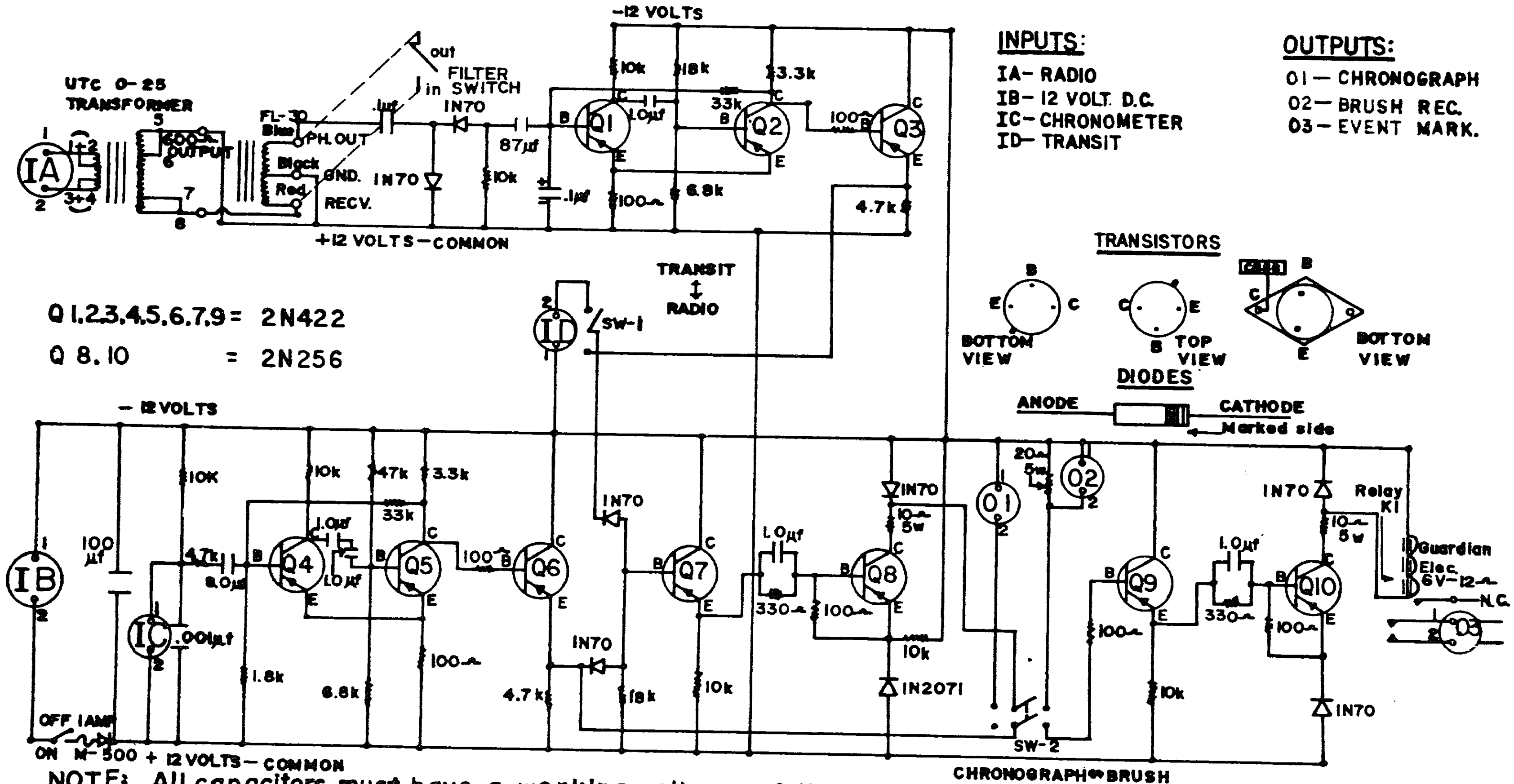
* Astro = Astrolabe; MT = Meridian Transit; PZT = Photographic Zenith Tube; ZT = Zenith Telescope.

APPENDIX E

SCHEMATIC OF ASTROAMPLIFIER

This appendix contains a schematic of the most frequently used astronomic amplifier. There are many types of amplifiers and any of them may be used as long as they are equivalent to the one shown in this appendix. The equipment and parts necessary to construct this amplifier are common to most electronic repair shops.

AMPLIFIER, ASTRONOMIC, TRANSISTORIZED



NOTE: All capacitors must have a working voltage of 15-volts or higher. All resistors are 1/2-watt, unless otherwise specified.

Figure E-1. Schematic of astroamplifier.

GLOSSARY

he following glossary is is an extract from the IA Manual "Glossary of Mapping, Charting, and eodetic Terms", July 1967. This extract includes ly those words and definitions that are pertinent r use with this Technical Manual.

berration—The apparent angular displacement of the position of a celestial body in the direction of motion of the observer, caused by the combination of the velocity of the observer and the velocity of light. See diurnal aberration.

curacy—The degree of conformity with a standard, or the degree of perfection attained in a measurement. Accuracy relates to the quality of a result, and is distinguished from precision which relates to the quality of the operation by which the result was obtained.

parent—A term used to designate certain measured or measurable astronomic quantities to refer them to real or visible objects, such as the sun or a star.

parent Altitude—The observed vertical angle to a star, planet, or to the sun, uncorrected for refraction or for reduction to a position at earth's center (parallax).

arent Horizon—The irregular line along which rays from the point of observation are tangent to the surface of the earth. The apparent horizon is the line where the visible surface of the earth appears to meet the sky.

arent Motion—Motion relative to a specified or implied reference point which may itself be in motion. The expression usually refers to movement of celestial bodies as observed from the earth.

arent Position—An astronomical term applied to the observable position of a star, planet, or the sun. The position on the celestial sphere at which a heavenly body (or a space vehicle) would be seen from the center of the earth at a particular time. Also called apparent place.

rent Sidereal Time—The local hour angle of the true vernal equinox.

rent Solar Day—The interval of time from a transit of the apparent sun across a given meridian to its next successive transit across the same meridian.

Apparent Solar Time—Time measured by the apparent diurnal motion of the true sun.

Astronomic Azimuth—The angle between the astronomical meridian plane of the observer and the plane containing the observed point and the true normal (vertical) of the observer, measured in the plane of the horizon clockwise from the elevated pole.

Astronomical Date—Designation of the epoch by year, month, day and decimal fraction. For example the astronomical date of December 21, 1966, 18^h UT is 1966 December 21.75 UT.

Astronomical Day—A mean solar day beginning at mean noon, 12 hours later than the beginning of the civil day of the same date. The civil day is now generally used.

Astronomical Equator—The line on the surface of the earth whose astronomical latitude at every point is 0°. Due to the deflection of the vertical (plumb line), the astronomical equator is not a plane curve. However, the verticals at all points on it are parallel to one and the same plane, the plane of the celestial equator; that is, the zenith at every point on the astronomical equator lies in the celestial equator. When the astronomical equator is corrected for station error, it becomes the geodetic equator.

Astronomical Latitude—The angle between the plumb line and the plane of the celestial equator. Also defined as the angle between the plane of the horizon and the axis of rotation of the earth. Astronomical latitude applies only to positions on the earth and is reckoned from the astronomical equator (0°), north and south through 90°. Astronomical latitude is the latitude which results directly from observations of celestial bodies, uncorrected for deflection of the vertical (plumb line).

Astronomical Longitude—The angle between the plane of the celestial meridian and the plane of an initial meridian, arbitrarily chosen. Astronomical longitude is the longitude which results directly from observations on celestial bodies, uncorrected for deflection of the vertical (plumb line).

Astronomical Position—1. A point on the earth whose coordinates have been determined as a result of observations of celestial bodies. The expression is usually used in connection with positions on land determined with great accuracy for survey purposes. 2. A point on earth, defined in terms of astronomical latitude and longitude.

Astronomical Refraction—The apparent displacement of an object that results from light rays from a source outside the atmosphere being bent in passing through the atmosphere. This results in all objects appearing to be higher above the horizon than they actually are. The magnitude of this displacement is greater when the object is near the horizon and decreases to zero when the object is at the zenith.

Astronomical Triangle—The triangle on the celestial sphere formed by arcs of great circles connecting the celestial pole, the zenith, and a celestial body. The angles of the astronomical triangles are: at the pole, the hour angle; at the celestial body, the parallactic angle; at the zenith, the azimuth angle. The sides are: pole to zenith, the colatitude; zenith to celestial body, the zenith distance; and celestial body to pole, the polar distance. Also called the PZS triangle.

Atmospheric Refraction—The refraction of light passing through the earth's atmosphere. Atmospheric refraction includes both astronomical and terrestrial refraction.

Azimuth Angle—The angle less than 180° between the plane of the celestial meridian and the vertical plane containing the observed object, reckoned from the direction of the elevated pole. In astronomic work, the azimuth angle is the spherical angle at the zenith in the astronomical triangle which is composed of the pole, the zenith, and the star. In geodetic work, it is the horizontal angle between the celestial pole and the observed terrestrial object.

Besselian Star Numbers—Constants used in the reduction of a mean position of a star in an apparent position (used to account for short-term variations in the precession, nutation, aberration, and parallax).

Broken-Telescope Transit—A precise astronomic transit or theodolite in which the light passing through the objective is reflected through a right angle by a prism placed in the trunnion axis.

Celestial Coordinates—Any set of coordinates used to define a point on the celestial sphere.

Celestial Equator—The great circle on the celestial sphere whose plane is perpendicular to the axis of rotation of the earth.

Celestial Geodesy—The branch of geodesy which utilizes observations of near celestial bodies, including earth satellites, to determine the size and shape of the earth.

Celestial Horizon—That circle of the celestial sphere formed by the intersection of the celestial sphere and a plane through the center of the earth and perpendicular to the zenith-nadir line.

Celestial Latitude—Angular distance north or south of the ecliptic; the arc of a circle of latitude between the ecliptic and a point on the celestial sphere, measured northward or southward from the ecliptic through 90°, and labeled N or S to indicate the direction of measurement.

Celestial Longitude—Angular distance east of the vernal equinox, along the ecliptic or the angle at the ecliptic pole between the circle of latitude of a point on the celestial sphere, measured eastward from the circle of latitude of the vernal equinox, through 360°.

Celestial Meridian—An hour circle of the celestial sphere, through the celestial poles and the zenith. The two intersections of the celestial meridian with the horizon are known as north and south points.

Celestial Pole—Either of the two points of intersection of the celestial sphere and the extended axis of earth.

Celestial Sphere—A sphere of indefinitely large radius, described about an assumed center, and upon which positions of celestial bodies are projected along radii passing through the bodies. For observations on bodies within the limits of the solar system, the assumed center is the center of the earth. For bodies where parallax is negligible, the assumed center may be the point of observation.

Center of Instrument—The point on the vertical axis of rotation of an instrument at the same elevation as the axis of collimation when that axis is in a horizontal position. In a transit or theodolite, it is close to or at the intersection of the horizontal and vertical axis of the instrument.

Chronograph—An instrument for producing a graphic record of time as shown by a clock or other device. In use, a chronograph produces a double record: the first is made by the associated clock and forms a continuous time scale with significant marks indicating periodic beats of the timekeeper; the second is made by some external agency, human or mechanical, and records the occurrence of an event or of a series of events.

Chronometer—A portable timekeeper with compensated balance, capable of showing time with extreme precision and accuracy.

Circumpolar—Revolving about the elevated pole without setting. A celestial body is circumpolar when its polar distance is approximately equal to or less than the latitude of the observer.

Clock Correction—The quantity which is added, algebraically, to the time shown by a clock to obtain the time of a given meridian. If the clock is slow, the correction is positive; if fast, negative. When applied to a chronometer it is called chronometer correction.

Clock Rate—The amount gained or lost by a clock in a unit of time. When applied to a chronometer, it is called chronometer rate.

Coaltitude—The complement of altitude, or ninety degrees minus the altitude. The term has significance only when used in connection with altitude measured from the celestial horizon, when it is synonymous with zenith distance.

Codeclination—The complement of the declination, or ninety degrees minus the declination. When the declination and latitude are of the same name, codeclination is the same as polar distance measured from the elevated pole.

Colatitude—The complement of the latitude, or ninety degrees minus the latitude. Colatitude forms one side, zenith to pole, of the astronomical triangle. It is the side opposite the celestial body.

Collimation—To render parallel to a certain line or direction; to render parallel, as rays of light; to adjust the line of sight or lens axis of an optical instrument so that it is in its proper position relative to the other parts of the instrument.

Constant of Aberration—The maximum aberration of a star observed from the surface of the earth, 20.49 seconds of arc.

Crystal Clock—A device for keeping accurate time. It consists essentially of a generator of constant frequency controlled by a resonator made of quartz crystal, with suitable methods for producing continuous rotation to operate time-indicating and related mechanisms.

Culmination—The position of a heavenly body when at highest apparent altitude; also for a heavenly body which is continually above the horizon, the position of lowest apparent altitude. Culmination occurs when the body transits the local meridian.

Curvature Correction—(Astronomy) A correction applied to the mean of a series of observations on a star or planet to take account of the divergence to the apparent path of the star or planet from a straight line.

Declination—In a system of polar or spherical coordinates, the angle at the origin between a line to a point and the equatorial plane, measured in a plane perpendicular to the equatorial plane. The arc between the equator and the point measured on a great circle perpendicular to the equator. The angular distance to a body on the celestial sphere measured north or south through 90° from the celestial equator along the hour circle of the body. Comparable to latitude on the terrestrial sphere.

Deflection of the Vertical—The angular difference, at any place, between the upward direction of a plumb line (the vertical) and the perpendicular (the normal) to the reference spheroid. This difference seldom exceeds 30 seconds. Often expressed in two components, meridian and prime vertical.

Deflection of the Vertical Correction—The correction due to deflection of the vertical, resulting from irregularities in the density and form of the earth. Deflection of the vertical affects all astronomic observations.

Depressed Pole—The celestial pole below the horizon, of opposite name to the latitude.

Diurnal Aberration—Aberration resulting fr the rotation of the earth on its axis. The va of diurnal aberration varies with the latitu of the observer and ranges from zero at the poles to 0.31 second of arc at the equator.

Ecliptic—The great circle formed by the intersection of the plane of the earth's orbit around the sun (or apparent orbit of the sun around the earth) and the celestial sphere.

Elongation—The angular distance of a body of the solar system from the sun; the angle at the earth between lines to the sun and another celestial body of the solar system.

Ephemeris Time—The uniform measure of time defined by the law of dynamics and determined in principal from the orbital motions of the planets, specifically in the orbital motion of the earth as represented by Newcomb's "Tables of the Sun".

Epoch—1. A particular instant for which certain data are given. 2. A given period of time during which a series of related acts or events takes place. 3. An arbitrary moment in time to which measurements of position for a body or orientation for an orbit are referred.

Equation of the Equinox—The difference between the mean and true right a[illegible] on the equator, thus the difference between mean and apparent sidereal time.

Equation of Time—The algebraic difference in hour angle between apparent solar time and mean solar time, usually labeled + and —, as it is to be applied to mean solar time to obtain apparent solar time.

Equinox—One of the two points of intersection of the ecliptic and the celestial equator, occupied by the sun when its declination is 0°.

Geoid—The figure of the earth considered as a sea-level surface extended continuously through the continents. The actual geoid is an equipotential surface coincident with mean sea level to which, at every point, the plumb line (direction in which gravity acts) is perpendicular. It is the geoid which is obtained from observed deflections of the vertical and is the surface of reference for astronomical observations and for geodetic leveling.

Great Circle—A circle on the surface of the earth, the plane of which passes through the center of earth.

Greenwich Apparent Time—Local apparent time at the Greenwich meridian.

Greenwich Hour Angle (GHA)—Angular distance west of the Greenwich celestial meridian; the arc of the celestial equator, or the angle at the celestial pole, between the upper branch of the Greenwich celestial meridian and the hour circle of a point on the celestial sphere, measured westward from the Greenwich celestial meridian through 360°; local hour angle at the Greenwich meridian.

Greenwich Meridian—The meridian through Greenwich, England, serving as the reference for Greenwich time, in contrast with local meridian. It is accepted almost universally as the prime meridian, or the origin of measurement of longitude.

Greenwich Sidereal Date—The number of mean sidereal days that have elapsed on the Greenwich meridian since the beginning of the sidereal day that was in progress at Greenwich mean noon on January 1, 4713 B.C.

Greenwich Sidereal Day Number—The integral part of the Greenwich sidereal date. It is a means of numbering consecutively successive sidereal days beginning at the instants of upper transit of the mean vernal equinox over the Greenwich meridian.

Greenwich Sidereal Time (GST)—Local sidereal time at the Greenwich meridian. The arc of the celestial equator, or the angle at the celestial pole, between the upper branch of the Greenwich celestial meridian and the hour circle of the vernal equinox, measured westward from the upper branch of the Greenwich celestial meridian through 24 hours; Greenwich hour angle of the vernal equinox, expressed in time units.

Hour Angle—Angular distance west of a celestial meridian or hour circle; the arc of the celestial equator, or the angle at the celestial pole, between the upper branch of a celestial meridian or hour circle and the hour circle of a celestial body or the vernal equinox, measured westward through 360°.

Hour Circle—Any great circle on the celestial sphere whose plane is perpendicular to the plane of the celestial equator.

Kepler's Laws—The three laws governing the motions of planets in their orbits. These are: (1) The orbits of the planets are ellipses, with the sun at a common focus; (2) As a planet moves in its orbit, the line adjoining the planet and the sun sweeps over equal areas in equal intervals of times; (3) The squares of the periods of revolution of any two planets are proportional to the cubes of their mean distances from the sun.

Laplace Azimuth—A geodetic azimuth derived from an astronomic azimuth by use of the Laplace equation.

Laplace Condition—The Laplace condition, expressed by the Laplace equation, arises from the fact that a deflection of the vertical in the plane of the prime vertical will give a difference between astronomic and geodetic azimuth; or, conversely, that the observed differences between astronomic and geodetic values of the longitude and of the azimuth may both be used to determine the deflection in the plane of the prime vertical.

Local Hour Angle—Angular distance west of the local celestial meridian; the arc of the celestial equator, or the angle at the celestial pole, between the upper branch of the local celestial meridian and the hour circle of a point on the celestial sphere, measured westward from the local celestial meridian through 360°.

Lower Branch—That half of a meridian or celestial meridian from pole to pole which passes through the antipode or nadir of a place.

Magnitude—Relative brightness of a celestial body.

Mean Solar Time—Time measured by the diurnal motion of a fictitious body, termed the mean sun, which is supposed to move uniformly in the celestial equator, completing the circuit in one tropical year. Often termed simply the mean time. The mean sun may be considered as moving in the celestial equator and having a right ascension equal to the mean celestial longitude of the true sun.

Meridian Altitude—The altitude of a celestial body when it is on the celestial meridian of the observer, azimuth 000° or 180°.

Meridian Angle—Angular distance east or west of the local celestial meridian; the arc of the celestial equator, or the angle at the celestial pole, between the upper branch of the local celestial meridian and the hour circle of a celestial body, measured eastward or westward from the local celestial meridian through 180°, and labeled E or W to indicate the direction of measurement.

Meridian Distance—The hour angle of a celestial body when close to but not exactly on the astronomic meridian. This term appears to be limited to computation forms where it is used to designate the hour angle of a star observed slightly off the meridian in making latitude observations by the zenith telescope (Sterneck or Horrebow-Talcott) method.

Nadir—The point on the terrestrial sphere directly beneath the observer and directly opposite to the zenith; the lowest point.

Normal—1. A straight line perpendicular to a surface or to another line. 2. A condition of being perpendicular to a surface or line. 3. In geodesy, the straight line perpendicular to the surface of the reference spheroid. 4. The average, regular, or expected value of a quantity.

North American Datum of 1927—The initial point of this datum is located at Meades Ranch, Kansas. Based on the Clarke spheroid of 1866, the geodetic positions of this system are derived from a readjustment of the triangulation of the entire country, in which Laplace azimuths were introduced.

Nutation—Irregularities in the precessional motion of the equinoxes because of varying positions of the moon and, to a lesser extent, of other celestial bodies with respect to the ecliptic.

Objective Lens—In telescopes and microscopes, the optical component which receives light from the object and forms the first or primary image. In a telescope or microscope used visually, the image formed by the objective lens is magnified by the eyepiece.

Ocular Micrometer—A filar micrometer so placed that its wire moves in the principal focal plane of a telescope.

Parallactic Angle—The angle between a body's hour circle and its vertical circle.

Parallax—1. The apparent displacement of the position of a body, with respect to a reference point or system, caused by a shift in the point of observation. 2. The apparent displacement between objects on the earth's surface due to their differences in elevation.

Personal Equation—The time interval between the sensory perception of a phenomenon and the motor reaction thereto. A personal equation may be either positive or negative, as an observer may anticipate the occurrence of an event, or wait until he actually sees it occur before making a record. This is a systematic error, treated as the constant type.

Personnel Error—An error caused by an individual's personal habits, his inability to perceive or measure dimensional values exactly, or by his tendency to react mentally and physically in a uniform manner under similar conditions. Contrasted with blunder; mistake.

Plumb Line—The line of force in the geopotential field. The continuous curve to which the direction of gravity is everywhere tangential.

Polar Distance—Angular distance from a celestial pole; the arc of the hour circle between a celestial pole, usually the elevated pole, and a point on the celestial sphere, measured from the celestial pole through 180°. Also called codeclination.

Polaris—The second-magnitude star, Alpha, in the constellation Ursa Minor (Little Dipper). Also known as the north star; polestar.

Precession—Change in the direction of the axis of rotation of a spinning body, as a gyroscope, when acted upon by a torque. The direction of motion of the axis is such that it causes the direction of spin of the gyroscope to tend to coincide with that of the impressed torque.

Precession in Declination—The component of general precession along a celestial meridian, amounting to about 20.″0 of arc per year.

Precession in Right Ascension—The component of general precession along the celestial equator, amounting to about 46.″1 of arc per year.

Precession of the Equinoxes—The conical motion of the earth's axis about the normal to the plane of the ecliptic, caused by the attractive force of the sun, moon, and other planets on the equatorial protuberance of the earth.

Precision—The degree of refinement in the performance of an operation, or the degree of perfection in the instruments and methods used when making the measurements. Precision relates to the quality of the operation by which a result is obtained, and is distinguished from accuracy which relates to the quality of the result.

Prime Meridian—The meridian of longitude 0°, used as the origin for measurement of longitude. The meridian of Greenwich, England, is almost universally used for this purpose.

Prime Vertical Circle—The vertical circle through the east and west points of the horizon.

Prime Vertical Plane—The plane perpendicular to the meridian plane containing the normal. The intersections of the astronomical prime vertical plane with the horizon are the east and west points.

Sidereal—Of or pertaining to the stars. Although sidereal generally refers to the stars and tropical to the vernal equinox, sidereal time and sidereal day are based upon the position of the vernal equinox relative to the meridian.

Sidereal Day—The interval of time from a transit of the (true) vernal equinox across a given meridian to its next successive transit across the same meridian.

Sidereal Focus—The position of the principal focal plane of a lens system. A camera or telescope is in sidereal focus when incident rays from a great distance come to a focus in the plane of the reticle.

Sidereal Hour Angle (*SHA*)—Angular distance west of the vernal equinox; the arc of the celestial equator, or the angle at the celestial pole, between the hour circle of the vernal equinox and the hour circle of a point on the celestial sphere, measured westward from the hour circle of the vernal equinox through 360°.

Sidereal Time—Time based upon the rotation of the earth relative to the vernal equinox.

Sidereal Year—The period of one apparent revolution of the earth around the sun, with respect to the stars, averaging 365 days, 6 hours 9 minutes, 9.55 seconds, and increasing at the rate of 0.000095 second annually.

Solar Day—1. The interval of time from the transit of either the sun or the mean sun across a given meridian to the next successive transit of the same body across the same meridian. 2. The duration of one rotation of the sun.

Solar Time—Time based upon the rotation of the earth relative to the sun.

Subpolar Stars—Stars that are on the opposite side of the celestial pole from the observer.

Transit—The apparent passage of a star or other celestial body across a defined line of the celestial sphere, as a meridian, prime vertical, or almucantar. The apparent passage of a star or other celestial body across a line in the reticle of a telescope, or some line of sight. The apparent passage of a smaller celestial body across the disk of a larger celestial body. The transit of a star across the meridian occurs at the moment of its culmination, and the two terms are sometimes used as having identical meanings; such usage is not correct, even where the instrument is in perfect adjustment. At the poles, a star may have no culmination but will transit the meridian.

Tropical Years—The interval of time between two successive passages of the vernal equinox by the sun. The tropical year is the year of the seasons, and the basis of the conventional calendar year.

UTO Time—Uncorrect Universal Time. (See also UT1 time; UT2 time).

UT1 Time—The true angular rotation of the earth about its instantaneous spin axis in the mean equatorial system of dates. UT1 is obtained from UTO by correcting UTO for the difference between the instantaneous and the mean longitude at the observing station. Since UT1 is keyed precisely to the instantaneous rotation of the earth, which is not strictly uniform, UT1 does not progress uniformly.

UT2 Time—The mean angular motion of the earth, freed of predictable periodic variations but still affected by irregular variations and secular variations. UT2 is obtained from UT1 by correcting UT1 for seasonal variations in rotation rate.

Upper Branch—That half of a meridian or celestial meridian from pole to pole which passes through a place or its zenith.

Upper Transit—Transit of the upper branch of the celestial meridian.

Vernal Equinox—That point of intersection of the ecliptic and the celestial equator, occupied by the sun as it changes from south to north declination, on or about March 21. Same as first point of Aries.

Zenith—That point of the celestial sphere vertically overhead.

Zenith Distance—The vertical angle between the zenith and the object which is observed or defined.

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